Exploring the Short-Sleep Obesity Association in Young Children

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by

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Abstract

There is strong and consistent epidemiological evidence that short sleep duration is associated with increased risk of obesity from early childhood. Childhood obesity and inadequate sleep have negative consequences for health and well-being, and the ability to target both of these public health concerns with a novel obesity intervention involving sleep extension is appealing; yet little is known about the mechanisms linking short sleep with obesity. In adults, hormonal mechanisms have been proposed; in young children, behavioural mechanisms and parenting are likely to be involved. Furthermore, the wider social and cultural determinants of short sleep and obesity should be incorporated into sleep-obesity research. This study aimed to explore some aspects of the sleep-obesity link in preschool children, using an exploratory design with a mixture of quantitative and qualitative methods, and applying an evolutionary medicine perspective.

Participants were 109 3-year-old children and their parents in Stockton-on-Tees. Children's sleep (validated by actigraphy), food intake and activity over 4 days/5 nights were assessed by parental diary report, and body composition was measured. Parents' attitudes were explored using semi-structured interviews.

Combined daytime and nighttime sleep duration was associated with central fat. Alternate parenting strategies were identified, based on regulation and consistency (routine-led), or child-governance and lack of regulation (routine-free). Building on the trends identified and the literature reviewed, I propose two hypotheses to explain the short sleep-obesity link in young children: the Behavioural Mechanisms Hypothesis (dietary and activity behaviours mediate or confound the association), and the Parental Confounding Hypothesis (parenting strategies, which vary with SES, impact on both children's sleep duration and obesity risk). Parenting impacts children's health by either limiting or facilitating discordance between children's experiences in evolutionarily novel environments, and their biological make-up. I conclude that sleep-based obesity interventions should consider the wider context of children's behaviours, particularly strategies of parenting.

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Abbreviations

ALSPAC	Avon Longitudinal Study of Parents and Children
BME	British Minority Ethnic
BMI	Body Mass Index
CI	Confidence Interval
ESRC	Economic and Social Research Council
ID	Identification Number (used to anonymously identify participants)
MRC	Medical Research Council
NOO	National Obesity Observatory
OR	Odds Ratio
SD	Standard Deviation
SES	Socioeconomic Status
SPSS	Statistics Package for Social Scientists
TV	Television
UK	United Kingdom
WHO	World Health Organisation

Declaration

I declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due acknowledgement has been made in the text. I confirm that no part of the material presented in this thesis has previously been submitted by me or any other person for a degree in this or any other institution.

Statement of Copyright

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Date:

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I dedicate this to you.

Chapter 1: Introduction

Observation: Short Sleep is Associated with Obesity

Recently, a large number of epidemiological studies have demonstrated an association between short sleep duration and obesity in the general population. This association has been consistent across studies involving large samples, in different countries and continents, prospective cohorts, and controlling for potential confounding factors including markers of SES, and dietary and activity variables. The link is particularly strong and consistent for young children, with a significant dose-response relationship between sleeping hours and risk of obesity. Prospective cohort studies have shown that sleep in young children has a lasting impact on obesity risk for years to come.

This short sleep-obesity association may explain a significant amount of variation in obesity (Young 2008, see Chapter 2) and be of great consequence for public health. The relationship has led to calls for obesity interventions to target sleep duration in children (Taheri, 2006). This is an attractive option, since it has the potential to positively influence two areas of child health: obesity and sleep sufficiency.

The Significance of the Sleep-Obesity Link for Public Health

Obesity is a major public health concern, due to the adverse consequences for health, the recent dramatic increase in prevalence, and the lack of effective large-scale interventions for treatment or prevention. Childhood obesity is particularly worrying due to the onset of adverse consequences in early life, and the persistence of obesity throughout childhood and into adulthood.

Consequences of Obesity

Obesity is an excess of body fat, which results in increased risk of morbidity (Reilly, 2005). The short-term and long-term adverse consequences of obesity are numerous, including risk of diabetes mellitus, hypertension, coronary artery disease, and some cancers (Solomon & Manson, 1997). There is a wealth of evidence demonstrating that the link between obesity and cardiovascular risk factors extends to childhood, including risk of hypertension, dyslipideaemia, and insulin resistance in obese children (Reilly et al., 2003b; Reilly, 2005), and progression to type 2 diabetes (Dea, 2011; Ludwig & Ebbeling, 2001). For example, in 5-10 year-old children, Freedman et al. (1999) found a high prevalence of cardiovascular risk factors in obese children: 58% of obese children had one cardiovascular risk factor, and 25% had two or more risk factors. Other adverse consequences of obesity include psychological ill health, such as low self esteem and behavioural problems (Dietz, 1998; Strauss, 2000). Children as young as 5-years-old can develop a negative self-image as a result of being overweight (Davison & Birch, 2001).

There is a trend for obesity to persist throughout childhood and into adulthood, particularly in children whose parents are also obese, leading to obese children suffering the adverse consequences of adult obesity (Reilly et al., 2003b). The effect begins in children as young as preschool age: 60% of children who were overweight at preschool age were overweight at age 12 years in a sample of 1042 American children (Nader et al., 2006). Another study found that just under 70% of obese pre-pubertal children will become obese adults (Whittaker et al., 1997). Furthermore, obesity in childhood is associated with cardiovascular risk factors in adulthood (Reilly et al., 2003b). A British cohort study found that adults who were overweight in childhood were at twice the risk of death from heart disease over 57 years of follow up (Gunnell et al., 1998). It is therefore particularly important to prevent obesity from early childhood.

Prevalence of Obesity

The prevalence of overweight and obesity has increased dramatically in recent decades, causing it to be termed an “epidemic” (Reilly & Dorosty, 1999). Prevalence has increased worldwide, but the increase has been most dramatic in economically developed countries (Wang & Lobstein, 2006); and a recent study has suggested that the British are the most overweight in Europe (Mooney, 2010). In the UK, according to national health survey data, the prevalence of obesity in children aged 2-10 years increased in boys from 3.1% in 1995 to 6.9% in 2007, and in girls from 5.2% to 7.4% across the same period; the 2015 projected prevalence is 10.1% for boys and 8.9% for girls (Stamatakis et al., 2010). In preschool children in particular, the 2008 Health Survey for England reported that 16% of preschool boys and girls were overweight, and 8% of boys and 11% of girls obese. The increasing prevalence of obesity has financial implications and is a burden on health systems (Russell et al., 2011).

Within England, obesity is particularly prevalent in the North-East. National data in 2005 revealed that the North-East had the highest level of overweight and obesity in 2-15 year-old children (Crowther et al., 2005). Obesity prevention interventions are therefore particularly needed in North-East England.

Obesity Interventions

The dramatic increase in prevalence of child overweight and obesity, coupled with the array of negative health consequences, necessitates clinical and public health action (Koplan & Dietz, 1999). Current interventions mainly focus on nutritional education, exercise and behavioural interventions (Wadden & Stunkard, 2002). However, treatments for obesity have been largely ineffective (Ebbeling et al., 2002), usually yielding only small reductions in body weight which are often not sustained over time (Stice et al., 2006). This, coupled with the persistence of obesity with increasing age, means that public health efforts should focus on prevention of obesity. Prevention efforts should begin in early childhood: the preschool years have been identified as a critical time to study the determinants of childhood obesity (Dietz, 1997), and a period where the trajectory of obesity begins (Blair et al., 2007). A recent systematic review found few obesity interventions in very young children (less than 2-years-old), and concluded that "*for clinically important and sustainable effect, future research should focus on designing rigorous interventions that target young children and their families*" (Ciampa et al., 2010, p. 1098).

There is limited evidence surrounding the effectiveness of preventative interventions. A Cochrane Systematic Review examined 22 studies designed to prevent obesity in childhood by modifying lifestyle and behaviours. The authors concluded that studies combining dietary and physical activity approaches did not significantly improve BMI; some studies focusing on diet or physical activity showed a positive impact on BMI status, but this was small (Summerbell et al., 2005). Novel interventions to target childhood obesity are necessary, and could have a significant impact on public health. Lengthening sleep has been identified as one such potential intervention, which is particularly attractive due to the additional potential benefits of improving sleep.

Sleep

In addition to an association with obesity, insufficient and problematic sleep is associated with an array of adverse health and behavioural consequences. Despite this, sleep is a relatively under-recognised area of children's health. Whilst the importance of a healthy diet and regular exercise is widely recognised, sleep is relatively neglected, despite the numerous conditions associated with insufficient sleep, and concerns that a large proportion of children do not achieve sufficient sleep.

Health Correlates of Sleep

Adequate sleep is necessary for optimal functioning and well-being. In healthy children, correlations have been found between poor or insufficient sleep and neurobehavioural functioning and behaviour regulation (Sadeh et al., 2002, 2003). In a community sample of preschool children, disrupted sleep predicted less optimal adjustment, as assessed by behaviour reports by teachers (Bates et al., 2002). Sleep is linked to performance of working memory in children as young as 6-years-old (Steenari et al., 2003), and to learning and academic performance in older children. A review by Curcio et al. (2006) concluded that sleep quantity and quality are closely related to learning capacity and academic performance, with some studies showing sleep loss to have a negative association with learning, memory capacity and school performance. Children with sleep disturbance have particular problems with focused attention, vigilance, reaction time, executive functioning and memory (Mindell et al., 1999). In young children, sleep regulation is associated with motor development (Scher, 2005). Furthermore, in healthy young children aged 3-7 years, sleep disturbances were associated with higher rates of accidental injury (Owens et al., 2005).

There is a well-established correlation of problematic sleep with Attention-Deficit Hyperactivity Disorder (Gruber et al., 2000), including in preschool children (Kaplan et al., 1987). Studies have also consistently found that childhood sleep problems are associated with mental health and psychiatric disorders, including mood and anxiety (Stores, 1992; Stein et al., 2001; Fallone et al., 2002; Mindell et al., 1999). The direction of causality of many of these associations of sleep is undetermined; however, there is some longitudinal evidence that sleep during the preschool years impacts on functioning later in life. For example, Wong et al. (2004) found that parent-reported sleep problems at age 3-5 years were associated with drug and alcohol abuse at age 12-14 years; and Gregory et al. (2005) reported that persistent sleep problems in childhood, as early as age 5 years, were associated with anxiety disorder at age 21 and 26 years.

Importantly, children's sleep impacts not only on children themselves, but also other members of the family. For example, sleep problems in infancy are correlated with poorer maternal health and well-being (Bayer et al., 2007). Multiple studies have documented adverse effects on parental sleep and daytime functioning related to sleepiness in families with children with sleep disorders (Owens et al., 1999a). Maternal depression, marital discord and child abuse have all been liked to children's sleep problems (Galland & Mitchell, 2010). Furthermore, Mindell & Durand (1993) found that treatment of sleep disorders in preschool children resulted in improvements in parents' mood, marital satisfaction and total sleep time; and in another study, quality of children's sleep significantly predicted the quality of their mothers' sleep, which was in turn a predictor of maternal mood, stress and fatigue (Meltzer & Mindell, 2007). Successful behavioural intervention for sleep problems in children with severe sleep problems and also learning disabilities and challenging behaviour resulted in improved sleep in their mothers also (Wiggs & Stores, 1998), in addition to reduced stress and increased perceived control and ability to cope in mothers. Interestingly, the effects of successful interventions with children differed between mothers and fathers, although both had increased satisfaction in their own and their children's sleep (Wiggs & Stores, 2001).

In sum, interventions to improve sleep in young children, in addition to having the potential to lower obesity prevalence, may have the potential to positively influence other aspects of children's health and development, and also the well-being of the wider family.

Inadequate Sleep

There are data to indicate that sleep duration has decreased in recent decades, across all age groups including young children. For example, Iglowstein et al. (2003) reported that between 1974-78 and 1986-93, daily sleep duration in Swiss children aged between six months to 14 years decreased by 20-40 minutes. Up to a quarter of young American children may now achieve inadequate sleep for their age, based on national recommendations (Owens & Jones, in press). Concerns that a large proportion of children do not achieve adequate sleep are exacerbated by reports of a high prevalence of sleepiness; for example, in 199 school children, over 80% reported that they felt sleepy for 2 or more days a week (Amschler & McKenzie, 2005). The concept of adequate sleep is vague, since judgements about what constitutes desired or adequate sleep are influenced by culture and social expectations (Wiggs, 2007); however, these findings suggest that interventions to improve sleep may be beneficial in the general paediatric population.

Conclusion

Obesity is a major public health concern due to the negative associations with health and the recent dramatic increase in prevalence. Current interventions generally target dietary and activity behaviours, but there is a need for novel preventative interventions. Additionally, adequate sleep is necessary for optimal health and development in children. Interventions to lengthen sleep may be particularly timely since sleep is low on the medical agenda, and it is feared that a large proportion of children do not achieve adequate sleep.

The ability to target both of these public health concerns in light of the sleep-obesity link is clearly significant. Lengthening sleep has the potential to form a novel intervention to reduce childhood obesity, whilst simultaneously resulting in improved sleep-related health, educational outcomes and development in children, and well-being of the whole family. The sleep-obesity link is strongest in young children, with prospective studies demonstrating that sleep in young children is associated with obesity in later years, and it has been suggested that the effects of short sleep on obesity may become difficult to reverse if interventions are not implemented in early life (Spruyt et al., 2011). This coincides with calls for obesity prevention efforts to begin in early childhood. It is therefore important to explore the sleep-obesity relationship in young, preschool-aged children.

Future Directions: Research Objectives and Aims

Given the robustness of the sleep-obesity link in epidemiological studies, and the need for effective interventions to reduce obesity, researchers have suggested that "*sleep should be recommended to prevent obesity*" (Taheri, 2006). Whilst this is an attractive option, there are limitations in the sleep-obesity literature which should be overcome by further research before it is concluded that lengthening sleep will reduce obesity in children, and in order for interventions to be designed and implemented effectively.

Particularly, the mechanisms linking short sleep with obesity in children are unclear. Adult sleep restriction studies have identified hormonal mechanisms which could link short sleep with increased appetite and food intake, leading to weight gain (see Chapter 2); however, these processes have not been replicated with children. Furthermore, sleep and obesity are influenced by a broad array of family, social and cultural factors; these have been neglected in sleep-obesity research, which to date has generally taken a focussed approach to quantify the link. A wider, more holistic approach is needed, in order to generate deeper insight into the childhood sleep-obesity link and the underlying mechanisms.

Specifically, behavioural mechanisms may play a role, and have received relatively little attention. Additionally, there are a number of potential confounding factors which have not been considered in sleep-obesity research, such as parenting. Sleep-obesity studies have examined the relationship in isolation, controlling for crude markers of SES (including household income and parents' education level), rather than looking at the broader social and cultural context. A holistic approach, including consideration of wider family, social and cultural characteristics, is lacking.

Taking the topic of the sleep-obesity relationship, an exploratory study is needed, in order to examine the relationship in detail, to identify trends, and generate hypotheses regarding the mechanisms behind the link. Exploratory studies enable deeper understanding of a topic, without the constraints of preconceived explicit hypotheses. In particular, qualitative investigation into the sleep-obesity link has been lacking; an exploratory study integrating both qualitative and quantitative techniques has the potential to enable more detailed and thorough understanding of the topic. Therefore, an objective of this study was to:

- OBJECTIVE ONE: Conduct a detailed exploratory investigation into the link between short sleep and obesity in preschool children.

Evolutionary Medicine

There is growing recognition of the importance of social and behavioural science in medicine, for example how family, cultural and ethnic influences shape health issues (Russell, 2009). Medical anthropology is an excellent perspective from which to explore the sleep-obesity link, since it considers the wider social and cultural processes surrounding health, and views health issues from multidisciplinary and ecological perspectives (McElroy & Townsend, 1989). Within medical anthropology, evolutionary medicine can provide new insights in health research, and shed light on the causes of ill-health. This approach uses an evolutionary perspective to understand why the body functions in the way that it does in different circumstances.

Much evolutionary medicine writing has focused on the incompatibility or mismatch between contemporary Western lifestyles and evolved human biology, and one of the best examples is obesity. In brief, the discordance between human biology (which has been shaped by dietary and lifestyle patterns during the 5-7 million years of hominid evolution) and modern Western lifestyles (which are drastically different, with abundant food and reduced physical work load) leads to weight gain and obesity (Trevathan et al., 2008). Despite the widely recognised evolutionary explanation for obesity, an evolutionary perspective been less widely applied to the study of sleep, and has not been applied at all to the relationship of obesity with short sleep. This study aimed to explore the childhood sleep-obesity link with an evolutionary medicine perspective, in order to add a new layer of insight and enable deeper understanding. This is an appropriate and prime perspective for exploratory research into health, since there is:

> *"A strong case for recognising evolution as a basic science for medicine…. Powerful insights from evolutionary biology generate new questions whose answers will help improve human health."* (Nesse et al., 2006, p. 1071)

In sum, evolutionary approaches can lead to more comprehensive understanding of poor health and the underlying causes, which can lead to new ways of treating and preventing ill health (Trevathan et al., 2008); hence a second objective of this study was to:

- OBJECTIVE TWO: Apply an evolutionary medicine perspective to the study of the sleep-obesity link.

Aims

The study objectives were addressed by conducting an exploratory investigation with a sample of 3-year-old preschool children and their parents in Stockton-on-Tees, North-East England. Specific aims were to:

- AIM ONE: Explore potential behavioural mechanisms linking short sleep and obesity in preschool children, particularly obesity-promoting dietary and activity behaviours
- AIM TWO: Explore the potential role of parenting in the childhood sleep-obesity link
- AIM THREE: Consider ethnicity and SES, and the wider impact of social and cultural attitudes and values in relation to the childhood sleep-obesity link

Besides lack of understanding of mechanisms and context, other limitations in the sleep-obesity literature include problems with sleep measures, such as lack of objective or validated methods of assessing sleep duration, lack of assessment of sleep over an extended period (including habitual variability in sleep), and omission of daytime sleep. Methods used to assess obesity are also problematic: the majority of studies have used BMI, which has limitations in assessing adiposity. Furthermore, defining short sleep or typical sleep in children is difficult due to the limited knowledge regarding children's sleep, and optimal sleep amounts at different ages. In order to expand on and contribute to the literature, the secondary aims of this study were to:

- SECONDARY AIM ONE: Improve on sleep measures used to examine the sleep-obesity relationship, particularly to assess sleep over a longer period (rather than a single night or parent-report of a typical night); assess variability in sleep duration (including week/weekend day and seasonal variation); and include naps in addition to nighttime sleep
- SECONDARY AIM TWO: Examine waist circumference and skinfold thickness in addition to BMI, to add to the growing body of literature examining relationships between sleep and more direct measures of central adiposity
- SECONDARY AIM THREE: Conduct a detailed investigation into sleep in a sample of preschool children, to add to the limited literature regarding children's sleep

The following two chapters will describe the rationale behind these aims and secondary aims in detail.

Summary

It has been observed that short sleep is associated with obesity in children. There is urgent need for effective interventions to reduce obesity prevalence, beginning in young children. Sleep is a potentially modifiable behaviour which could impact positively on an array of factors in addition to obesity. Further research into the sleep-obesity link in young children is needed in order to inform effective interventions. In particular, the mechanisms linking short sleep with obesity are unclear, and the wider family, social and cultural context has not been considered. Evolutionary medicine has the potential to enable novel insights into the sleep-obesity link, and is a good theoretical perspective for exploratory health research. The objectives of this study were to explore the sleep-obesity link in preschool children, and to apply an evolutionary medicine perspective.

The key to this investigation is that it was an exploratory study aiming to provide detailed insight into a health issue which has the potential to positively impact public health, and medical and social sciences. The lack of preconceived hypotheses meant that areas of interest and significance could be followed as they arose, without the limitation of having to follow a set analysis plan. The trade-off to this approach was that definitive conclusions could not be drawn; rather, models and mechanisms were built and proposed, to be analysed and tested in future research. Given the importance attributed to the sleep-obesity link, the calls for it to form the basis of public health interventions, and the relative lack of knowledge regarding the details, mechanisms and context of the link, an exploratory study with the ability to start to unpick mechanisms linking sleep and obesity was very much appropriate.

Thesis Outline

Chapter 2 will review the literature documenting a link between short sleep and obesity in young children. Key characteristics of the sleep-obesity link will be discussed, followed by limitations in the literature. Aspects of the sleep-obesity link which need to be explored in more depth will be identified, and improvements in methods used in sleep-obesity research will be proposed.

Chapter 3 will explore the literature in order to identify potential mechanisms linking short sleep and obesity in preschool children. Areas requiring further research will be discussed, and the chapter will conclude by presenting the specific aims of this study.

Chapter 4 will present the study design, including the study location, participants and recruitment, and the methodology used.

Chapter 5 will describe the sample, including characteristics of the children and their parents; and will present some initial analyses.

Chapters 6, 7 and 8 will present the results and discussion for different topics in turn (sleep; diet and activity; associations of sleep with diet and activity). Qualitative and quantitative results will be presented together, alongside discussion, so that each chapter can progress and build on previous results and discussion, building a model throughout the data analysis process. In accordance with the exploratory design, qualitative and quantitative results will be considered together, alongside existing literature, in order to generate hypotheses for future research.

Chapter 9 will interpret the results of the study using an evolutionary medicine perspective. It will then review the effectiveness of the study at meeting the research objectives and aims, discuss the limitations in the research, and outline suggestions for future research and policy.

Chapter 2: Literature Review: The Short Sleep-Obesity Link in Young Children

This chapter will review the literature documenting an association between short sleep duration and obesity in children. Specifically, this chapter will a) outline key aspects of the data, b) discuss limitations in the literature, including inconsistencies in sleep and obesity measures and definitions, and lack of determination of causality or mechanism, and c) summarise aspects of the sleep-obesity relationship which should be explored in more depth. Then Chapter 3 will explore the mechanisms and the context of the sleep-obesity link in detail, focusing on potential behavioural mechanisms, and reviewing the social, ethnic and cultural context of sleep and obesity.

Short Sleep is Associated with Obesity in Young Children

Over the past decade, a large number of epidemiological studies have demonstrated an association between short sleep duration and obesity in the general population. This association has been documented in children, adolescents and adults. In one of the largest studies, with over 1.1 million adults, Kripke et al. (2002) demonstrated that habitual sleep duration was associated with BMI: the association was inverse and linear in men, and U-shaped in women.

The link is particularly strong and consistent for young children. In 2008, authors of five separate reviews, including 3 systematic reviews, each concluded that there is strong, consistent evidence that children's short sleep duration is associated with obesity in populations around the world (Patel & Hu; Hart & Jelalian; Cappuccio et al.; Chen et al. al., Marshall et al.). For example, Patel & Hu (2008) found that in all of the studies they identified (11 cross-sectional and 2 longitudinal), spanning 5 continents, short sleep duration and obesity were positively associated. Studies have included large samples, of both boys and girls, in different countries and continents. The majority of studies have been conducted in general paediatric populations rather than clinic populations (for example children with sleep disorders or weight problems).

The relationship appears to be stronger among children of younger ages: Chen et al. (2008) concluded after conducting their systematic review that the association is strongest for children younger than 10-years-old. Bell & Zimmerman (2010) (see below) proposed that there is a critical window prior to age 5 years when sleep may be important for subsequent obesity status, after which the influence of sleep duration wanes. A critical window for prevention of obesity is also early childhood (see Chapter 1), and so the sleep-obesity relationship in young children is particularly important. Some cross-sectional studies which include children as young as 5-years-old are outlined in Table 2.1.

These epidemiological studies demonstrate that parent-reported sleep duration is consistently associated with obesity across different populations of children. The association is linear and negative, and some studies show a clear dose-response relationship between hours of sleep and obesity prevalence. For example, in the Toyama Birth Cohort Study (Sekine et al.), there was a dose-response relationship so that for each hour of sleep less than 11 hours, there was an increase in obesity. Similarly, the large German study by von Kries et al. demonstrated a dose-response relationship. This linear relationship differs to adult women, for which a U-shaped relationship is thought to exist (with long as well as short sleep duration being associated with increased risk for obesity).

In addition to these cross-sectional studies, a number of prospective studies have shown that short sleep duration in young children is associated with obesity later in childhood. This is important because unlike cross-sectional studies, longitudinal studies can establish the temporal pattern of events and indicate causality. Longitudinal studies that include children as young as preschool age are summarised in Table 2.2.

Table 2.1: Cross-sectional Studies Documenting as Association between Short Sleep and Obesity in Young Children

Lead Author	Year	Age of Sample (Years)	Country	Sample size (n)	Measure of Sleep Duration	Measure of Overweight/ Obesity	Summary of Findings	Potential Confounders Considered in Analyses
Chaput	2006	5-10	Quebec	422	Parent questionnaire: usual bedtime and wake time on week days	BMI cut offs for overweight and obesity	Compared to 12-13 hours sleep, adjusted OR for overweight/obesity: 1.42 (1.09-1.98) for 10.5-11.5 hours, 3.45 (2.61-4.67) for 8-10 hours	Age, sex, parent obesity, education, income, frequency of breakfast, sport, and TV viewing
Chaput	2007	5-8	Quebec	422	Parent questionnaire: usual bedtime and wake time during the week	Waist Circumference	Significant negative correlation between sleep duration and waist circumference (r=-.17, p<.001)	BMI, parent obesity, parent education and income, frequency of breakfast consumption, frequency of sport, TV viewing
Jiang	2009	3-4	China	1311	Parent questionnaire: usual bedtime and wake time	BMI cut off for obesity	Compared with 11 or more hours sleep, OR for obesity: 4.76 (1.28-17.69) for <9 hours, 3.42 (1.12-10.46) for 9.0-9.4 hours	Age, sex, birthweight, parental education, income
Kagamimori	1999	3	Japan	9668	Parent questionnaire: usual bedtime and wake time	BMI cut off for obesity	Obese children were significantly more likely to sleep less than 10 hours (p<.001)	
Locard	1992	5	France	1031	Parent interview: usual sleep duration	BMI cut off for obesity	Compared to over 12 hours sleep, adjusted OR for obesity: 2.0 (.9-4.4) for 11-12 hours, 2.8 (1.2-6.3) for 10-11 hours, 4.9 (1.9-12.7) for less than 10 hours	Parental obesity, excessive TV viewing, SES, breast-feeding

Table 2.1 continued

Author	Year	Age of Sample (Years)	Country	Sample size (n)	Measure of Sleep Duration	Measure of Overweight/ Obesity	Summary of Findings	Potential Confounders Considered in Analyses
Sekine	2002b	3	Japan	8941	Parent Questionnaire: usual bedtime, wake time, hours of naps	BMI cut off for obesity	Compared to 11 or more hours of sleep, adjusted OR for obesity: 1.20 (0.97-1.49) for 10-11 hours; 1.34 (1.05-1.72) for 9-10 hours, and 1.57 (0.90-2.75) for less than 9 hours	Parent obesity, age, sex, outdoor playing time
Shi	2010	5-15	Australia	3495	Parent questionnaire: usual hours of sleep	BMI cut off for obesity	Compared to 10 or more hours, OR for obesity for <9 hours was 1.97(1.15-3.38). The association was stronger in younger age group (5-10 years)	Socio- demographic variables, fruit and vegetable intake, physical activity
von Kries	2002	5-6	Germany	6862	Parent Questionnaire: usual bed time and wake time during the week	BMI cut-off for obesity, body fat cut off for high body fat (Bioelectrical impedance assay)	Compared to 10 h or less sleep, adjusted OR (95% CI) for obesity: sleeping 10.5-11.0 hours 0.52 (0.34-0.78); sleeping 11.5h 0.46 (0.28-0.75). Similar results for high body fat	Parent education, parent obesity, birth weight, excessive TV viewing, diet, snacking

Table 2.2: Longitudinal Studies Documenting as Association between Short Sleep and Obesity in Young Children

Lead Author	Year	Age of Sample	Country	Sample size (n)	Measure of Sleep Duration	Measure of Overweight/ Obesity	Summary of Findings	Potential Confounders Adjusted for
Agras	2004	sleep at 2, 3, 4, 5 years, overweight at 9.5 years	USA	150	Parent report: usual sleep time	BMI cut off for overweight	Short sleep at age 2-5 associated with overweight at age 9.5 years. Sleep duration a continuous variable: linear regression -.21	Age, SES, physical activity, TV viewing, diet, breastfeeding, parental obesity
Bell & Zimmer-man	2010	sleep in children aged 0-13 years, obesity 5 years later	USA	1930	Time diary	BMI cut offs for overweight and obesity	In younger cohort (0-4 years at baseline), short sleep (below 25th percentile) at baseline associated with obesity 5 years later, adjusted OR 1.80 (1.16-2.80)	Age, sex, birthweight, TV viewing
Reilly	2005	sleep at 3 years, obesity at 7 years	UK	8234	Parent questionnaire: duration of nighttime sleep	BMI cut off for obesity	Compared to >12 hours at age 30months, adjusted OR for obesity at age 7 years: 1.45 (1.10-1.89) for <.10.5 hours, 1.35 (1.02-1.79) for 10.5-10.9 hours, 1.04 (0.76-1.42) for 11-11.9 hours	Maternal education, energy intake at age 3, sex
Snell	2007	sleep in children aged 3-12 years, obesity 5 years later	USA	2281	Time diary	BMI continuous	Children who slept less at baseline had higher BMI and were more likely to be overweight 5 years later. For younger children (3-8 years), compared to 9-10 hours sleep, overweight/obesity for <8 hours 0.084 (logistic regression), for 8-9 hours 0.041, 10-11 hours -0.062, >11 hours -0.158	Gender, income, parent education, BMI at baseline
Taveras	2008	sleep at age 6 months, 1 year and 2 years (averaged), overweight at age 3 years	USA	915	Parent questionnaire: usual daily hours of sleep	BMI continuous and cut off for obesity, skinfold thicknesses	Less than 12 hours of sleep in infancy was associated with higher BMI, higher sum of skinfolds, and increased odds of overweight (OR 2.04, 1.07-3.91)	Maternal education, income, smoking, breastfeeding, birthweight, parental BMI, TV viewing, active play

These studies demonstrate that sleep duration in preschool-aged children is associated with risk of obesity in later childhood. For example, the Avon Longitudinal Study of Parents and Children (ALSPAC) showed in a large British cohort that short sleep duration at age 30 months predicted obesity at age 7 years (Reilly et al.). Smaller birth cohorts of American children also demonstrated a relationship between short sleeping hours in preschool children and subsequent obesity status (Agras et al., Bell et al., Snell et al.). Furthermore, Taveras et al. demonstrated that sleep duration in infancy predicted obesity in preschool children (aged 3). One study (Snell et al.) controlled for BMI at the time of the sleep assessment and found BMI 5 years later to be independently correlated with sleep, indicating that short sleep duration is associated with subsequent development of obesity, rather than maintenance of obesity in already obese children.

Both Bell & Zimmerman and Snell et al. reported the sleep-obesity relationship to be stronger for younger age groups (sleep at age 0-4 years, and age 3-8 years respectively), which supports the concept that the link is stronger for young children. Whilst the weight of evidence suggests a stronger relationship in young children, it should be noted that Bayer et al. (2009) examined trends in sleep with increasing age in relation to body fat, and found that the association was of a similar size between ages 3-10 years. However, the association of sleep duration at preschool age or younger with later childhood obesity confirms the significance of the preschool period and the need to examine the relationship in children of this age.

Further to the individual studies shown in Tables 2.1 and 2.2, two meta-analyses have been performed. Chen et al. (2008) identified 11 studies which met the criteria for inclusion in their meta-analysis, and calculated pooled odds ratios (OR): for each 1 hour increase in sleep duration, the pooled OR for overweight/ obesity was 0.91 (95% confidence interval (CI) 0.84-1.00). For young children (younger than 5-years-old), compared to sleeping for more than 11 hours, those who slept for 9-10 hours had higher risk of overweight/obesity, OR (95% CI) 1.60 (1.22-2.10), and those sleeping for less than 9 hours had much higher risk, OR 1.92 (1.15-3.20). Cappuccio et al. (2008) carried out a separate meta-analysis involving 29,502 children from 11 studies around the world. They dichotomised sleep for all studies, and the pooled OR for short sleep duration and obesity was 1.89 (1.46-2.43).

The sleep-obesity association is particularly strong in boys. The meta-analysis by Chen et al. (2008) supported a gender difference, with boys having a stronger inverse association than girls (OR 2.50 versus 1.24). The reasons for this are unclear: perhaps girls are more resilient to environmental stressors than boys. Wells (2000) proposed that natural selection has favoured differential affects of environmental stress on males and females into early childhood (more severe for males), due to males and females offering different returns for parents. Despite a gender difference in some studies, most have not reported a gender difference (Chen et al., 2008), and the relationship exists for both young boys and girls.

Importantly, potential confounding variables have been controlled for, and the association between short sleep duration and obesity remains significant (see below for a discussion of confounding). Risk factors for obesity in preschool children include parental obesity, high birthweight, lack of breastfeeding, maternal smoking in pregnancy (Reilly et al., 2005; Armstrong and Reilly, 2002; Dietz, 2001; Toschke et al., 2002); and dietary and activity behaviours (see Chapter 3). Furthermore, body composition varies with gender, and both obesity and sleep vary with age, SES and ethnicity (see Chapter 3). Studies have found short sleep to be associated with obesity independently of parental obesity, birthweight, breastfeeding, maternal smoking, age, gender, SES (parents' education, household income), and other factors (see Tables 2.1 and 2.2). For example, the cross-sectional study by von Kries et al. controlled for parental obesity, birthweight, excessive TV viewing and dietary factors, amongst other obesity risk factors, and found an independent dose-response relationship between sleeping hours and obesity. The longitudinal studies in Table 2.2 also controlled for potential confounding factors: for example, Agras et al. found sleep duration in young children to be associated with obesity in later childhood independently of age, parental obesity, SES, physical activity, TV viewing and diet.

Certain medical conditions (including chronic pain, medication use, and particularly psychiatric disorders) are associated with both sleep and obesity and may confound their association. Indeed, in children as young as 8-17 years-old, depression is correlated with both increased BMI and more fragmented sleep (Wojnar et al., 2010). However, studies with adults have controlled for medical conditions and found sleep and obesity to be significantly associated (Patel & Hu, 2008). For example, the Zurich

Cohort Study with adults investigated psychiatric conditions, including detailed assessments of depressive symptoms, and revealed that the sleep-weight association was independent of depression (Hasler et al., 2004). The potential of sleep disorders to cause the link between short sleep and obesity has also been examined (see below), with no strong suggestion that sleep disorders are causal of the sleep-obesity relationship. Less statistical control of potentially confounding medical conditions has been performed in studies with children compared to adults; however, these conditions are uncommon in young children, which reasons against them being the cause of the observed sleep-obesity relationship (Patel & Hu, 2008).

Sleep Duration versus Regularity, Sleep Quality and Disordered Sleep

Epidemiological studies have focused on the association of sleep duration with obesity. In a recent study, Spruyt et al. (2011) examined the association of obesity with regularity of sleep, as well as total sleep duration, in a sample of 308 children aged 4-10 years. They found that obese children were less likely to experience “catch up” sleep at weekends, and had more variance in night-to-night sleep duration. The authors concluded that a combination of shorter and more variable sleep patterns puts children at greatest risk of obesity; therefore regularity, as well as duration, may be important.

Any associations of obesity risk with sleep quality or disruption rather than sleep duration (and regularity) are less robust and inconclusive. For example, in a study of 383 American adolescents, Gupta et al. (2002) found that obesity was related to sleep duration, but not to sleep quality, as assessed by actigraphy. Similarly, Lumeng et al. (2007) studied 9-12 year-old children, and found that whilst overweight risk was associated with short sleep, there was no association with sleep problems.

A small number of studies have documented an association of sleep quality with obesity. For example, Beebe et al. (2007) demonstrated that overweight adolescents had more disrupted sleep in comparison to normal weight adolescents, in addition to shorter sleep duration. A marker of sleep quality is sleep efficiency, which is the ratio of time slept asleep to the amount of time spent in bed: Liu et al. (2008) reported a significant correlation between overweight and both sleep efficiency and total sleep time, as measured by polysomnography. In a prospective birth cohort study, BMI and obesity prevalence at age 21 years were greater for adults whose parents had reported sleep problems at ages 2-4 years, compared to those who had not had sleeping problems, after adjusting for maternal BMI, and adolescent diet and TV viewing habits (Al Mamum et al., 2007).

The majority of sleep-obesity literature has focused on sleep duration alone; but sleep quality and sleep disorders are important aspects of sleep that should not be ignored in a comprehensive investigation. Defining problematic sleep and sleep disorders in children is difficult. There are no standard criteria or clear definitions for childhood sleep problems, for example how many night wakings, how long and how frequent, are required for this to be considered problematic (Tikotzky & Sadeh, 2001). Also, parentally-defined problematic sleep is inherently subject to reporting bias and parentally-based values and beliefs, which again hinders definitions of sleep problems. The general criteria for sleep problems include frequent, severe and chronic symptoms of bedtime resistance and night wakings (Mindell et al., 2006), and the reported cross-cultural prevalence for parent-reported child sleep problems is around 25% (Owens, 2005).

Summary: Short Sleep is Associated with Obesity in Young Children

There are a wealth of epidemiological studies documenting a consistent and strong association between short sleep duration and obesity in the general paediatric population. These include both cross-sectional and longitudinal designs, with large sample sizes, in different countries around the world. The relationship is linear and dose-responsive, remains significant after controlling for potential confounding factors, and is strongest in young children.

Despite some data indicating that sleep problems or low sleep quality may be related to obesity, the results are conflicting and inconclusive. Comparatively, there is a wealth of evidence supporting an association of obesity with sleep duration rather than quality; hence sleep duration is the focus of this thesis.

The majority of sleep-obesity studies have documented an association of sleep duration with obesity in general populations. Accordingly, this study concerns children in a nonclinic population, rather than children diagnosed with sleep disorders, or with weight problems. With sleep duration as the principle focus, aspects of sleep quality (sleep onset latency and night wakings) and consideration of sleep problems will also be included in this study since they are important components of sleep.

Mechanisms Linking Short Sleep with Obesity

Whilst epidemiological studies demonstrate a clear association between sleep duration and obesity in children, the mechanisms by which short sleep may lead to obesity remain unclear. Indeed, the direction of causality itself is undetermined (see below for causality); although longitudinal studies suggest a causal association of sleep duration with obesity.

It is possible that short sleep alters hormone levels, leading to weight gain. In the Wisconsin Sleep Cohort Study of adults, short sleep duration was associated with levels of appetite-regulating hormones: compared to those habitually sleeping for 8 hours at night, adults who habitually slept for 5 hours had 15.5% lower leptin (an appetite suppressor) and 14.9% higher ghrelin levels (an appetite stimulant) (Taheri et al., 2004). Similar changes have been documented in laboratory studies of sleep restriction in young adults: short-term acute sleep deprivation (sleeping for 4 hours or less per day) has been shown to result in a decrease in leptin and an increase in ghrelin. These changes were correlated with increased hunger and appetite, further suggesting that sleep deprivation could lead to overeating and weight gain (Spiegel et al 2005; van Cauter et al., 2007; Schmid et al., 2008). It should be noted that sleep restriction studies are short-term; such acute sleep restriction is unsustainable, and it cannot be determined that the same effects exist for habitual short sleep in the general population.

No similar sleep restriction studies have been carried out with children, and so whether these hormonal mechanisms extend to childhood is undetermined. However, an association of children’s sleep duration with insulin resistance and glucose regulation has been documented. In obese children, Flint et al. (2007) found short sleep duration (measured by one-night polysomnography) to be associated with insulin resistance. In another study, with preschool children aged 3-6 years, short sleep duration was associated with fasting glucose level: compared to children who slept for 9-10 hours per night, those who slept for 8 hours or less had a significantly greater chance of having hyperglycemia (high blood sugar), even after controlling for SES, parental obesity, children's body composition, food intake and physical activity. In Spruyt et al.'s (2011) study (described above), a subgroup of children was tested for fasting morning plasma levels of glucose, insulin, and other metabolic markers. Irregular and short sleep was found to be associated with metabolic marker levels, leading the authors to suggest that irregular and short sleep increases risk for metabolic dysfunction.

These studies suggest that sleep duration in children as young as preschool age is associated with glucose regulation and insulin resistance, consistent with a causal role of short sleep in weight gain and development of obesity. Other hormones which are affected by short sleep and which could lead to weight gain include cortisol (which has a lipogenic property and could contribute to obesity) and growth hormone (which is reduced by sleep loss) (Taheri, 2006).

Laboratory studies with rodents have provided further evidence for a link of sleep with weight and energy expenditure. In rodents, periods of starvation are accompanied by increased vigilance and sleep loss (presumably to increase food finding), and sleep deprivation leads to increased energy expenditure and weight loss (Penev, 2007). Although these findings suggest an opposite association of sleep loss with obesity to humans (a negative rather than positive association), they indicate that sleep is involved in energy conservation and metabolism. In the evolutionary novel Western human environment, in which sleep loss is accompanied by excessive rather than restricted food intake, short sleep duration could have a negative impact on metabolic health and lead to weight gain. Further evidence that sleep is associated with food intake is described by Fuller et al. (2008): animals that have access to plentiful food have sleep patterns which follow the light-dark cycle; however, if animals have access to food only during their normal sleep cycle, then they shift their sleep patterns to match food availability.

In combination with epidemiological data, laboratory findings suggest that sleep is linked to appetite and metabolism, which can affect obesity risk. As well as increased general appetite and food intake, short sleep could lead to selection of calorie-dense foods in particular, which lead to weight gain (Taheri, 2006). Short sleep duration is related to increased fat intake (Shi et al., 2008), and experimental sleep restriction in adults has resulted in increased craving for high calorie foods (Spiegel et al., 2004). In adolescents, Landis et al. (2009) observed an unexpected positive association between daytime sleep and total food cravings and caloric intake. Cravings for carbohydrate-starch and high fat foods were greater in adolescents with increased daytime sleep. Increased daytime sleep was also negatively associated with nighttime sleep, and so these changes may be consistent with an association of short nighttime sleep with craving for high-calorie foods. (This study points out that daytime sleep ought not to be excluded from consideration, see below.)

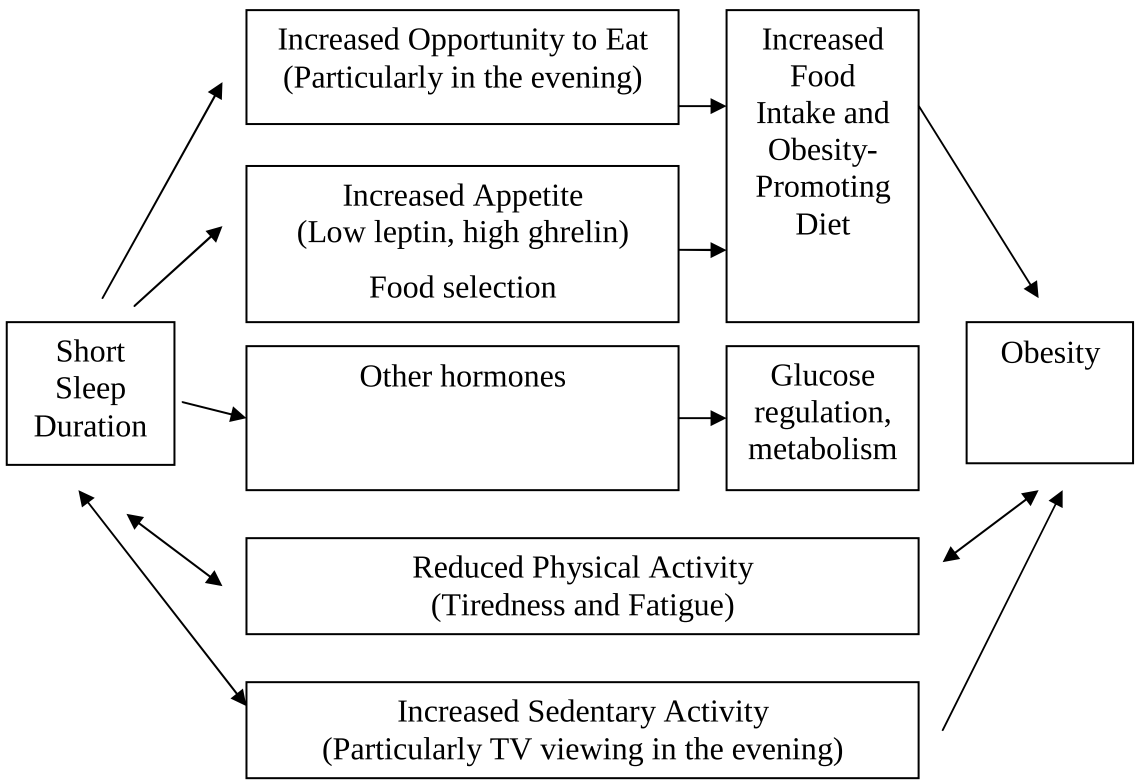
Further to hormonal changes, shorter sleep allows more opportunity to eat, since more time is spent awake. Short sleep duration often results from later bedtimes (see below), hence children who sleep for less may eat more particularly in the evening. Consistent with this hypothesis, a study of experimental sleep restriction in adults demonstrated that sleep restriction can modify the composition and distribution of food intake (Nedeltcheva et al., 2009): compared to when they slept for 8.5 hours, adults sleeping for 5.5 hours over 14 days had similar food intake during meals, but increased consumption of calories from snacks, which was most marked in the evening and nighttime period. Later bedtimes and obesity-promoting habits in the evening may therefore be particularly important in the sleep-obesity link.

Another pathway through which short sleep and obesity may be linked is physical activity. Sleep deprivation results in tiredness and fatigue; this could contribute to reduced daytime activity and obesity (Sekine et al., 2002b). Conversely, obesity may result in reduced physical activity, leading to shorter sleep time because less time is needed for recovery, and low physical activity levels are detrimental for sleep (Taheri, 2006; Vioque et al., 2000). No study has examined an interaction between short sleep duration and physical activity specifically; however, children who are less active have been found to have longer sleep onset latencies (Nixon et al., 2009) (sleep onset latency is the time taken to fall asleep after getting into bed). In examining the relationship between sleep duration and obesity in Australian children, controlling for potential confounding factors, Shi et al. (2010) found an additive interaction between short sleep and physical activity: children with both short sleep and low physical activity levels had the highest risk of obesity.

Sedentary activity, in addition to physical activity, may link sleep and obesity. In particular, TV viewing is thought to be a significant contributor to sleep deprivation in children (Taheri, 2006) and is also a risk factor for obesity (see Chapter 3). If short sleep results from late bedtimes (see below), short sleep is particularly likely to co-occur with increased TV viewing since most children's TV viewing occurs in the evening (Taheri, 2006). Again, obesity-promoting habits occurring in the evening in short sleepers may play a role in the sleep-obesity link.

The literature discussed above suggests pathways through which short sleep may be linked with obesity: these are summarised in Figure 2.1. (Note that bi-directionality of some arrows indicates lack of determination of causality, or possible bi-directionality.)

Figure 2.1: Potential Mechanisms Linking Short Sleep Duration with Obesity



There is growing interest in hormonal mechanisms that may link short sleep and obesity; these are the pathways discussed in most depth in the recent reviews of the sleep-obesity literature. Behavioural mechanisms (including dietary and activity behaviours) are potentially important yet overlooked. Particularly for young children, behavioural mechanisms, including parents' behaviours, may be important: this thesis will focus on possible behavioural mechanisms linking sleep with obesity (see Chapter 3).

Mediation, Causality and Confounding

The potential mechanisms described above imply that obesity-related behaviours may act as mediators in the pathway between short sleep and obesity. A mediator is a variable which explains how or why another variable (sleep) affects the outcome (obesity) (Kraemer et al., 2001) (see Figure 2.2).

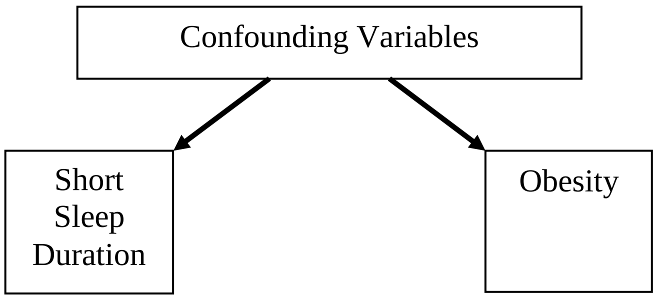
Figure 2.2: Obesity-Promoting Behaviours May Mediate the Sleep-Obesity Association

This pathway assumes that short sleep duration is causal to obesity (via mediating factors). This is in support of longitudinal studies suggesting that sleep duration predicts subsequent risk of obesity, and laboratory studies which have revealed a potential mechanism. However, it is not proven that short sleep leads to weight gain and obesity. There are no intervention or observation studies demonstrating that altering sleep duration leads to weight loss or weight maintenance.

It is possible that there is reverse causation, with obesity leading to short sleep duration. This could occur through obesity-induced co-morbidities; particularly, obesity is the strongest risk factor for obstructive sleep apnea, which leads to sleep disruption (Strobel & Rosen, 1996). Indeed, Beebe et al. (2007) compared sleep in overweight adolescents compared to a normal weight control group: the overweight group displayed more symptoms of sleep-disordered breathing in addition to shorter and more disrupted sleep. However, several studies with adults have controlled for co-morbidities such as sleep apnea in analyses and found the sleep-obesity link to be independent (for example Fogelholm et al., 2007). Furthermore, the association of sleep duration with obesity has been demonstrated in the general population rather than in clinic populations, and obesity-induced disorders are rare in children. The relationship is therefore not likely to be significantly attributed to obesity-related disorders; the weight of evidence suggests that short sleep leads to obesity.

It is also possible that the sleep-obesity relationship arises due to confounding by other factors, which influence both sleep and obesity. Confounding variables would independently impact on both sleep and obesity, making them appear to be correlated (see Figure 2.3).

Figure 2.3: Independent Variables May Confound the Sleep-Obesity Association



Studies have attempted to control for potential confounding factors (including age, gender, SES, parental obesity, dietary and activity habits, and medical conditions) and the sleep-obesity relationship has remained significant (see above). However, the degree of control for such factors, and the way in which they are assessed, has been inconsistent (Cappuccio et al., 2008).

There are other factors which could confound the link between sleep and obesity which have not been considered in research to date. Sleep is influenced by social norms and cultural context, as are dietary and activity habits, which contribute to obesity risk (see Chapter 3). For young children, parenting behaviours may be an important confounder; for example, parenting style is implicated in overweight and obesity, and parenting behaviours also influence sleep (see Chapter 3).

It is important to explore possible confounding factors, because they may reveal that the sleep-obesity relationship is spurious rather than causal, which has implications for interventions targeting obesity prevention or treatment through sleep. To date, research has focussed on quantifying the sleep-obesity link, controlling for specific possible confounding factors. As discussed in Chapter 3, sleep and obesity are shaped by a complex web of family, social and cultural influences, and the sleep-obesity link needs to be considered in this wider context, exploring the potential role of other confounding factors.

Summary: Mechanisms Linking Short Sleep with Obesity

The mechanisms which link short sleep with obesity are not well understood. Laboratory studies have revealed a potential pathway in adults: sleep restriction alters appetite and food intake, leading to weight gain. Potential behavioural mechanisms have not been determined, but may play a role in the relationship; and independent variables may confound the sleep-obesity link. Further research is needed in order to understand how sleep and obesity are related, whether the relationship is direct, and to confirm whether the association is in fact causal. This thesis will explore potential behavioural pathways and confounding variables.

Limitations in the Sleep-Obesity Literature

Whilst an association between short sleep duration and obesity in young children has been demonstrated to be strong and consistent, in large samples, in different populations across the world, in prospective cohorts, and independent of potential confounding factors, there are limitations in the literature which need to be assessed before it can be definitively concluded that short sleep causes obesity. As discussed above, causality has not been confirmed, and there is a lack of understanding of mechanism(s), along with the possibility of unknown mediating or confounding factors. Further limitations include methodological issues, and variation in definitions of short sleep and obesity.

Limitations in Sleep Measures

Sleep-obesity research is inconsistent in sleep duration measures used. Different methods have been applied, and there are different definitions regarding sleep duration.

Methods of Measuring Sleep Duration

The vast majority of published sleep-obesity studies in young children have used parent report as the measure of children's sleep duration. All of the cross-sectional studies in Table 2.1 used parental questionnaires to measure sleep duration on typical nights, either directly, or from reported bedtime and wake times. Three of the longitudinal studies in Table 2.2 similarly used parental report of typical sleep duration, and two used time diaries for specific periods.

Parental report is problematic because questions are often not validated, are not comparable across studies, and produce different estimates of sleep duration compared to objective measures such as polysomnography and actigraphy (see Chapter 4). Indeed, the definition of "sleep duration" varies according to the method used. The studies in Tables 2.1 and 2.2 differed between asking for typical sleep duration, or for bedtime and wake time from which to calculate nighttime sleep duration. These measures inherently include some time awake in bed, including time taken to get to sleep once in bed (sleep onset latency), and time spent awake after sleep onset (night wakings). Comparatively, objective measures such as polysomnography and actigraphy include only time spent asleep in their estimate of sleep duration, excluding sleep onset latency, and duration of night wakings.

Even when parent-report measures of sleep duration account for night wakings, the inability of parents to accurately report the frequency and duration of these wakings can result in different values to those obtained by objective methods. Although parents can accurately report sleep schedules, including sleep onset and wake time, they tend to underestimate night wakings, which can lead to parents overestimating nighttime sleep duration in comparison with actigraphy and polysomnography (Tikotsky & Sadeh, 2001).

There is also variability between different methods of self-report sleep duration. Knutson & Lauderdale (2007) assessed sleep duration in 1546 adolescents aged 10-19 years using both time diaries and self-reported sleep hours. The two measures were weakly correlated, and whilst time-diary sleep duration was not significantly associated with overweight, self-reported sleep duration was. Although their study concerned self-report by adolescents, rather than parent-report for young children, it demonstrates the importance of the sleep assessment method used for the outcomes and conclusions of sleep-obesity research.

Despite concerns, parent-report has been favourably validated against objective measures for the assessment of children's sleep duration. For example, Sekine et al. (2002a) reported that whilst parents tended to overestimate sleep in their young children (aged 3-4 years) compared to actigraphy, there was high correlation between the 2 measures, indicating that parent-report estimates of sleeping hours could be used in surveys examining relative differences in sleeping hours in a population.

Unfortunately, objective measurements of sleep duration have not been extensively used in sleep-obesity research, either with children or adults. Two studies with older children have assessed sleep duration objectively using actigraphy. Gupta et al. (2002) measured sleep duration using 24-hour actigraphy in their cross-sectional sample of 383 adolescents aged 11-16 years. They found that for each hour of lost sleep, the odds of obesity increased by 80%, independently of potential confounding factors. Nixon et al. (2008) assessed sleep duration in 519 7-year-old children using 24-hour actigraphy: short sleep duration (<9 hours) was associated with being overweight/ obese (OR 3.32, 1.40-7.87), and an increase of 3.34% body fat, independently of physical activity and TV viewing. These actigraphy studies parallel the relationship between parent-reported sleep and obesity. However, they are limited by the use of actigraphy for 24-hour periods only. A period of 5 nights is recommended to ensure reliability (Acebo et al., 1999), and it is possible that a 24-hour period of actigraphy, similarly to single parent-report estimates of usual sleep patterns, is not representative of usual sleep behaviours, and masks night-to-night variability (see below). In contrast, in Spruyt et al.'s (2011) study (described above), actigraphy over 1 week was used to examine the association of sleep with obesity. Obese children slept for less at weekends, and had more night-to-night variability in sleep duration. Further research using objective or validated measures of sleep, over extended periods of time, are needed to strengthen the sleep-obesity literature.

Despite limitations in the methods used to assess sleep duration, studies have been consistent in their conclusions. Short sleep duration has been associated with obesity when using parent-report (typical sleep duration; typical bedtime and wake time; time diaries) and actigraphy.

Sleep Variability

Parent reports of typical sleep duration, and assessment of sleep duration in a single 24-hour period, are unable to account for habitual variability in sleep. This includes variability between weekdays and weekends; for example, Snell et al. (2007) reported week night sleep duration to be 10:30 hours at age 3 years, and weekend night sleep duration to be almost 11:00 hours. In addition, sleep patterns have been found to vary in school children between schooldays versus holidays (Wing et al., 2009, Szymczak et al., 1993). There is also indication of variability across seasons: Thorleifsdottir et al. (2002) found that in children aged 1-5 years, nighttime and total sleep was shorter in spring than winter; and 7-year-old children have been documented as having shorter sleep in the summer compared to other seasons (Nixon et al., 2008).

These reports of habitual variability are important because night-to-night or seasonal variation in sleep may affect the sleep-obesity link. Wing et al. (2009) examined variation in school children's (age 5-15 years) sleep on weekdays, weekend days and holidays in relation to the sleep-obesity link. They found that the increase in BMI in children with short sleep was reduced when children compensated for short weekday sleep with longer sleep at weekends or holidays; thus compensation of sleep during weekends or holidays may partly ameliorate the risk of overweight/ obesity. This complements Spruyt et al.'s (2011) finding that obese children were less likely to experience "catch up" sleep on weekends.

Olds et al. (2010) looked at the relationship between sleep duration and weight status in school children (aged 9-18 years) across 4 different day types: S-S (to bed and waking on school days), S-NS (to bed on school day and waking on non-school day), NS-S (to bed on non-school days and waking on school day), and NS-NS (to bed and waking on non-school days). Obesity was associated with sleep duration, but the relationship varied with day type: the association was particularly strong on NS-S days, and was not significant on S-NS days. One hypothesis proposed by the authors is that a third factor (such as screen time or physical activity) contributes to overweight and short sleep in a way that interacts with day time (for example, screen times were longer on NS days).

Whilst the studies of Spruyt et al., Wing et al. and Olds et al. considered variability across day types, the majority of sleep-obesity research has not. Few studies have differentiated between sleep duration on week and weekend days, and it is unclear how accurately people can average sleep habits over week and weekend days into a single question. Furthermore, their studies were with school children: since different sleep patterns on different days have been documented in children as young as preschool age, habitual variability in sleep needs to be incorporated into sleep-obesity research in young children.

There is also some evidence that sleep amounts are not stable across time: children who have short sleep at one time point do not necessarily have short sleep across their whole childhood. Observational studies which have used repeated measures of self-report sleep duration demonstrate substantial variability in these reports over time (see Marshall et al., 2008). Hence there have been calls for studies to assess sleep duration at different time points in relation to obesity risk.

Napping

Another limitation in the majority of sleep measures in the sleep-obesity literature is the failure to include daytime napping. Sekine et al. (2002b) and Agras et al. (2004) included daytime napping in addition to nighttime sleep, but the majority of studies have included only measures of nighttime sleep duration. The importance of omitting daytime napping from sleep duration measures is demonstrated by a study of French adults over the age of 60 years (Ohayon & Vecchierini, 2005). Obesity was associated with short sleep duration; however, obese subjects were also more likely to report daytime napping, and so there was no association of total daily sleep duration with obesity.

For young children, where napping is more common, its omission from sleep-obesity studies may be even more important. Indeed, Agras et al. (2004) found that children who were overweight at age 9.5 years had slept for on average 30 minutes less per day between ages 3-5 years compared to those who remained normal weight, and this difference was almost entirely due to disparities in daytime napping, with only 5 minutes difference in nighttime sleep.

Contrastingly, Bell & Zimmerman (2010) examined independently the relationship between nighttime and daytime sleep duration and weight status in young children; in preschoolers, short nighttime sleep predicted subsequent obesity, but daytime sleep had little effect. The authors concluded that napping had no effect on obesity development, and is not a substitute for adequate nighttime sleep.

Little is known about the functions of napping in young children, and the consequences of consolidated versus combined nighttime and daytime sleep (Crosby et al., 2005). There is some suggestion that nighttime sleep and daytime naps have different physiological functions: nighttime sleep has complex biological, psychosocial and restorative functions; daytime naps reduce psychosocial stress, and increase attention span and alertness (Bell & Zimmerman, 2010; Ward et al., 2008a).

There is individual variability in napping behaviour so that by age 3 years, some children do not frequently nap, whilst others sleep for over 2 hours each day. In a nationally representative sample of 493 Swiss children (Iglowstein et al., 2003), 50% of 3-year-old children did not nap during the day, whilst for 96% of those who did nap, daily duration ranged from 0.8-2.6 hours.

The degree to which variability in napping behaviour is biologically-determined is not well understood. Mindell et al. (2010) examined sleep in young children from 17 different countries and found that whilst there was great variability in nighttime sleep duration, daytime sleep was more consistent, with all children in the study following the same maturation pattern in napping behaviours. This, they concluded, indicates a biological contribution to daytime sleep, which is stronger and less culturally-influenced than is nighttime sleep. Sadeh et al. (2008) also concluded that daytime sleep in their sample of children aged 0-3 years was mostly determined biologically, by age, whilst nighttime sleep was more strongly predicted by ecological factors (see Chapter 3 for a discussion of ecological influences on sleep).

Both Ward et al. (2008b) and Weissbluth (1995) examined sleep and napping behaviours in young children, and concluded that the majority of children nap when given the opportunity. Ward et al. (2008b) found that most of the preschool children in their sample napped when provided the opportunity at day-care; the authors even proposed that an opportunity to nap could benefit most preschool children. Weissbluth (1995) reported that when parents maintain nap routines, children continue to nap. Furthermore, modal nap duration from age 2 to 6 years in Weissbluth's (1995) cohort was relatively consistent, despite variation in caretaking and social activities: this led to the author's conclusion that nap duration has a biological basis in children, which supports Mindell et al.'s (2010) and Sadeh et al.'s (2008) claims.

The lack of understanding of napping, coupled with the significant influence of daytime sleep in some sleep-obesity studies, demonstrates the need to incorporate daytime as well as nighttime sleep into sleep-obesity research in order to gain a comprehensive understanding of the relationship between sleep duration and obesity status.

Summary: Limitations in Sleep Measures

Sleep-obesity studies with young children have used parental report of sleep duration, which has some inherent limitations. Few studies have accounted for variability in sleep duration, including week/ weekend variation, variation with holiday days, and seasonal variation. Additionally, few studies have included daytime napping in addition to nighttime sleep in their estimation of sleep duration.

Limitations in sleep-obesity research due to methods used to assess sleep are ameliorated by the consistency of results. When using different methods to assess sleep duration, either accounting for variability in day types or not, and including nighttime sleep only or combined nighttime and daytime sleep, the results are consistent and uniform, which increases confidence in the conclusion that short sleep duration and obesity are significantly linked.

Future research should include objective or validated measures of sleep duration, across a longer period (rather than a single night or parent-report of a typical night), assessing variability in sleep duration (for example across different day types, and seasonally), and including naps in addition to nighttime sleep, in order to unpick the relationship between sleep and obesity in more detail. This thesis will build on previous research into the sleep-obesity link by fulfilling some of these suggestions.

Definitions of Short versus Normal Sleep

Epidemiological studies and reviews agree that short sleep duration is associated with obesity. However, definitions of normal or short sleep duration differ greatly, which reflects the lack of understanding of the optimal amount of sleep for children of different ages. In Patel & Hu's (2008) review, definitions of short sleep duration ranged from less than 8 hours to less than 11 hours per night between studies.

Normative Sleep Amounts

Normative data on children's sleep duration are scarce, and sleep need or optimal sleep amounts at specific ages are not determined. It is recognised that sleep need varies as a function of children's age: duration declines from infancy to later childhood and adolescence (Iglowstein et al., 2003; Sadeh et al., 2000). Various studies have aimed to determine sleep amounts in representative population samples in order to elucidate the typical duration of sleep in children at different ages. However, examining the sleep duration of a population may help to determine the typical sleep patterns of children, but this does not necessarily indicate sleep need or whether these sleep amounts are optimal for health and development (Wiggs, 2007). Perhaps children "get by" on less than optimal sleep, or are able to extend sleep further than they need. Since typical sleep durations in a population may not reflect optimal or adequate sleep amounts, it is perhaps more helpful to examine sleep-related outcomes in relation to sleep duration in order to determine optimal sleep amounts. There is some suggestion that a large proportion of children do not obtain adequate or optimal sleep (Hart & Jelalian, 2008), supported by the increase in sleep duration when children are given the opportunity (for example on weekends), and the high prevalence of sleepiness (see Chapter 1).

Furthermore, there are large individual differences in sleep amounts within age groups and populations, indicating that sleep need is not uniform for the entire population of children, and that the search for a universal sleep need may be in vain (Ferrara & DeGennaro, 2001). Iglowstein et al. (2003) aimed to calculate sleep duration at different ages in a nationally representative sample of Swiss children: at age 3 years, 96% of children slept for an average of between 10.3-14.8 hours over a 24 hour period. This range of 3.5 hours in sleep duration per day indicates great variability and difficulty in applying a universal sleep need to all 3-year-old children.

Cross-Cultural Sleep Amounts

Further complications in determining sleep need, or the optimal amount of sleep for children, include lack of understanding of the consistency of sleep duration cross-culturally. Data regarding sleep amounts for children in different countries may not be applicable to children in the UK, and children from different ethnic groups in the UK may not have the same sleep need.

Mindell et al. (2010) examined sleep patterns in children aged 0-3 years in 17 countries, which were classed as either predominantly-Caucasian (Australia, Canada, New Zealand, UK and USA), or predominantly-Asian. Overall, children from predominantly-Caucasian countries had significantly earlier bedtimes and longer sleep compared to those from predominantly-Asian countries, ranging from an average total daily sleep duration of 11.62 hours in Japan, to 13.31 hours in New Zealand. UK children had the third longest daily sleep duration of any country (13:06 hours).

In their analysis of an American National Survey of Children’s Health, Smaldone et al. (2007) found non-Hispanic white children to have shorter sleep compared to non-Hispanic black, Hispanic or children of other ethnicities. Crabtree et al. (2005) documented later bedtimes and less sleep in African-American compared to Caucasian children aged 2-7 years. Sadeh et al. (2009) also found white American children up to age 3 years to have longer nighttime sleep compared to children of other ethnicities. Within Britain, ethnic variation in sleep is evident: in English and Scottish school children, Rona et al. (1998) documented disturbed and poor sleep to be more likely in children from the Indian subcontinent and other ethnic minorities compared to white British children.

Cross-cultural variation in distribution of sleep across the day has also been reported. In American preschool children, age-related decline in napping was more gradual for black children than for white children (Crosby et al., 2005). Black children also napped on more days per week; in combination with shorter nighttime sleep, this led to similar total sleep time for black and white children (after controlling for confounding factors such as mothers' age and marital status).

The sleep-obesity relationship has been consistently found across different countries and continents. This indicates that although sleep amounts may or may not vary cross-culturally, the relationship of short sleep with obesity is maintained across different cultures and populations. Despite cross-cultural differences in sleep, Iglowstein et al. (2003) suggested that sleep needs are comparable amongst Western societies (including the USA, UK, and other European countries), due to similarities in childrearing and cultural influences. They propose that the same reference values for sleep can be applied to children in all Western societies.

Trends in Sleep Amounts

There are suggestions that population-level sleep duration has decreased over recent decades across different age groups, which provides further problems for determining normative sleep amounts and defining short sleep. The proportion of young Americans reporting less than 7 hours sleep per night rose from 15.6% in 1960 to 37.1% in 2002 (National Sleep Foundation, 2002). Dollman et al. (2007) reported that Australian children aged 10-15 years had a reduction in time in bed of 30 minutes between 1985 and 2004. There is some indication that decline in sleep has occurred for preschool children also: Iglowstein et al. (2003) reported that between 1974-78 and 1986-93, sleep duration in Swiss children aged between six months to 14 years decreased by 20-40 minutes.

Although these results suggest that habitual sleep duration in children has decreased in recent decades, caution is needed in drawing this conclusion. There is limited data on historical sleep amounts, and differences in measurements of sleep between studies means that direct comparisons cannot be drawn (Blunden, 2010). Moreover, since the optimal amount of sleep for children is unknown, the effect of any possible decline in sleep duration cannot be determined; for example, children may have previously slept for longer than was optimal, or they may still sleep within a healthy range.

Reference Values for Sleep Duration

The above discussion has demonstrated that there is no definitive sleep need for children, and highlighted some problems in estimating sleep need. This includes variation in sleep duration as measured by different methods, variation in sleep need across ages, the applicability of reference sleep amounts across Western societies, and the possible change in sleep amounts in recent decades. However, there are some data and recommendations for sleep amounts in preschool children, which are useful references to consider; relevant reference data for this study are shown in Table 2.3. The reference data shown include sleep duration data for preschool children, in recent years, as measured by parent report, in Western countries.

Table 2.3: Reference Data for Sleep Duration in Young Children

Lead Author	Childrens' Nationality	Childrens' Age	Sample Size	Measure of Sleep	Sleep Duration per 24 hours (hh:mm)
National Sleep Foundation	American	1-3	Recommendation		12:00-14:00
National Sleep Foundation	American	3-5	Recommendation		11:00-13:00
Iglowstein (2003)	Swiss	3	450	Parent Questionnaire	12:30
Sadeh (2009)	American & Canadian	2-3	700	Parent Questionnaire	11:54
Thorleifsdottir (2002)	Icelandic	2-3	70	Parent Diary & Questionnaire	11:20
Acebo (2005)	American	3	21	Parent Diary	11:40
Mindell (2010)	British	0-3	800	Parent Questionnaire	13:06

Daily sleep duration ranges from 11:20 to 13:06 hours in the reference samples, again reflecting the difficulty in determining definitive sleep need. Some of these are large and nationally representative samples; however, the data from Sadeh et al. and Mindell et al. were taken from internet-based surveys, which may have skewed participation in favour of well-educated, middle class parents; sleep for children of these groups of parents differs compared to those of less well educated and lower SES families (see Chapter 3).

The majority of the reference data refer to children in age groups, rather than 3-year-old children exclusively. Age ranges up to and including 3-years-old may overestimate sleep amounts for 3-year-old children, whilst estimates for age ranges with 3-year-olds as the youngest may underestimate their sleep amounts, because sleep duration decreases with age. This is mirrored by the National Sleep Foundation recommendations (American): based on guidelines and evidence base regarding sleep, they recommend that preschool children (aged 3-5 years) sleep for between 11-13 hours per night, with greater sleep amounts for children aged 1-3 years.

Reference data for prevalence and duration of daytime napping are shown in Table 2.4. Again, data are shown for preschool children, in Western societies, in recent years, measured by parental report.

Table 2.4: Reference Data for Prevalence and Duration of Napping in Young Children

Author	Children's Nationality	Children's Age (Years)	Sample Size	Measure	Proportion of Children Napping (%)	Mean Daily Nap Duration (hh:mm) (Excluding Non-nappers)
Acebo (2005)	American	3	21	Parent Diary	81	01:10
Crosby (2005)	White American	3	171	Parent Questionnaire	> 80	01:40
Iglowstein (2003)	Swiss	3	450	Parent Questionnaire	50	01:42
Weissbluth (1995)	American	3	172	Parent Questionnaire	92	02:06
					Whole Sample (Including Non-nappers)	
Mindell (2010)	British	0-3	800	Parent Questionnaire	02:37	
Sadeh (2009)	American & Canadian	2-3	700	Parent Questionnaire	00:53	

For two of the studies, the nap duration of only children who napped was not available, and so the duration shown includes both children who did and did not nap; it is therefore likely to be an underestimate of nap duration for nappers exclusively. The proportion of children napping ranges from half to almost all children across the different reference populations. Average nap duration for nappers is 1:10 hours or more per day.

Defining Short Sleep

The awareness that typical or optimal sleep amounts for children are not well understood is important for research demonstrating the link between short sleep and obesity. The definition of “short” sleep duration is unclear and inconsistent. Many studies have used cut-off values or categories for sleep duration, which are not based on biological sleep need, and vary between studies (see Tables 2.1 and 2.2). Despite limitations in the definition of short sleep, the pattern of results is consistent: when using single cut-off values to define short versus normal sleep, categories of varying sleep durations, or using sleep duration as a continuous variable, results consistently demonstrate that shorter sleep is associated with increased risk of obesity in children.

Summary: Definitions of Short versus Normal Sleep

The optimal amount of sleep for children at different ages is not determined. Difficulties in determining sleep need include large individual differences in sleep amounts, cross-cultural variation in sleep amounts and patterning, the suggested decrease in sleep amounts in recent decades, and lack of understanding of whether children receive adequate sleep, get by on too little sleep, or sleep for longer than they need. Hence there is inconsistency in definitions of short sleep across sleep-obesity studies.

Again, consistency in findings ameliorates these limitations: short sleep has been consistently associated with obesity when using different definitions of short sleep. Furthermore, although for adult women there is a U-shaped association of sleep duration with obesity, indicating that too much sleep in addition to too little sleep is detrimental for health, studies with children do not demonstrate this relationship. Rather, there is a linear relationship, with no documented negative consequences of too much sleep.

This thesis will add to the limited literature regarding children's sleep by providing a detailed investigation of sleep in a sample of preschool children.

Limitations in Obesity Measures

Further to inconsistency in sleep measures and definitions of short sleep, there is inconsistency in measures of body composition and definitions of obesity. Sleep-obesity studies have used a variety of methods to assess body composition and obesity, which reflects the current confusion and lack of consensus regarding the definition and measurement of childhood obesity (Bouchard, 2007).

A widely used definition for obesity, which is feasible for epidemiological use, is body mass index (BMI), calculated as weight/height^2 (kg/m^2). BMI has been recommended for monitoring of childhood obesity (Rudolf et al., 2006): it is a non-invasive, simple measure which is easy to obtain in young children (Manios et al., 2004; Reilly and Dorosty, 1999).

In adults, a cut off value of 30 kg/m^2 is recognised internationally as a definition of obesity (WHO, 1995). Obesity definitions in childhood are less straightforward due to the variation in fatness with age (Ebbeling et al., 2002): BMI rises during infancy, falls during preschool age, and then rises again until adulthood. Furthermore, there is natural variation in fatness and BMI across ethnic groups (Deurenberg et al., 2002).

BMI can be assessed using age-specific and population-specific reference data. The most commonly used reference charts in the UK are the British 1990 Growth Reference (Cole et al., 1990) and the International Obesity Task Force growth reference (Cole et al., 2000). Using appropriate reference data, raw BMI values can be standardized into z-scores or SD (standard deviation) scores. In order to categorise children as ideal weight, overweight or obese for their age, sex and height, commonly recommended definitions are a BMI equal to or above the 95th percentile to define obesity, and a cut off of the 85th percentile to define overweight. Alternatively, there are age- and sex-specific BMI cut-off points to define overweight and obesity (for example Cole et al., 2000). These use the national or international growth charts to determine the threshold for obesity at different ages, defined as the percentile which passes through a BMI of 30 kg/m^2 at age 18 years (because obesity in adults is defined as BMI of 30 kg/m^2 or more).

BMI is widely used, and is generally considered a good surrogate measurement for body composition in young children (Dencker et al., 2007). It is appropriate for identifying obesity in epidemiological studies since 1) it identifies the fattest children in the population relatively well, 2) it is associated with health outcomes, including morbidity in childhood, persistence of obesity into adulthood, and the clustering of cardiovascular risk factors (Reilly et al., 2003b), and 3) it is practical for large-scale use in population studies. Accordingly, the majority of sleep-childhood obesity studies have used BMI to assess body composition and obesity (see Tables 2.1 and 2.2).

However, BMI has some limitations for assessing fatness. It is not a precise indicator of the underlying proportion of fat and lean mass, meaning that it is not descriptive of body composition (Dietz & Bellizzi, 1999). Waist circumference and skinfold thickness may therefore be better measures to define overweight and obesity. Skinfold thickness is a more sensitive measure than BMI (Malina & Katzmarzyk, 1999), and has the advantage of being a more direct measure of adiposity (McCarthy et al., 2006). Furthermore, abdominal obesity is more strongly correlated with health problems than is peripheral or general obesity (Maffeis et al., 2001), including increased cardiovascular and metabolic risks in children (Li et al., 2006). Therefore measures of abdominal obesity, such as waist circumference, are considered by some to be better indicators of obesity than is BMI (Kragelund & Omlands, 2005); Dencker et al. (2007) recommended that waist circumference be used alongside BMI.

The inability of BMI to account for fat mass or abdominal obesity is a major limitation for its use in health research. Some sleep-obesity studies in children have included more direct measures of body composition (see Tables 2.1 and 2.2): for example, Taveras et al. measured skinfold thickness at different sites, von Kries et al. measured body fat using bioelectrical impedance assay, and Chaput et al. measured waist circumference. Each of these authors also assessed BMI, either in the same paper (Taveras et al., von Kries et al.) or a different paper (Chaput et al.). In each case, the association of sleep duration with the measure of fat mirrored its association with BMI: sleep duration was inversely associated with skinfold thickness, high body fat, and waist circumference. In the Quebec en Forme study (Chaput et al.), waist circumference was associated with sleep duration independently of BMI.

Bayer et al. (2010) examined the relationship between sleep duration and different markers of body fat in children aged 3-10 years. Body fat as measured by skinfold thickness and BMI were similarly related to sleep, leading the authors to conclude that variation in BMI according to sleep may be a consequence of fat mass in particular, and that fat rather than other tissues is associated with sleep. This is important because an association of sleep duration with adiposity is more significant for health outcomes than is an association with BMI alone, due to the stronger correlation with health. More direct measures of adiposity than BMI should continue to be used in sleep-obesity research.

A further problem with using BMI to define obesity is that estimates of obesity prevalence vary according to the reference data used, which is problematic for epidemiological studies and comparisons when different criteria have been used (Lang et al., 2011). Indeed, the sleep-obesity studies in Tables 2.1 and 2.2 used a variety of reference data and obesity cut-off values. Furthermore, some studies compared overweight, obese and non-obese groups, and others combined overweight and obese children and compared them to ideal weight groups. One study to date has examined underweight in addition to overweight, and the linear relationship between sleep duration and obesity extended to underweight (Olds et al., 2010). Whilst cut-off points are more commonly used to define overweight/ obesity, some studies have used BMI or standardised BMI scores as a continuous variable rather than categorised into weight status, for example Snell et al., Taveras et al.. When assessed continuously, BMI has still been significantly correlated with sleep duration.

Summary: Limitations in Obesity Measures

There is no consensus regarding the best method to assess childhood overweight and obesity. The vast majority of sleep-obesity studies have used BMI to define obesity; however, different studies have used different reference data and different cut-off points to define overweight and obesity. BMI does not account for fat versus lean mass, and is not a direct measure of central adiposity, meaning that it is not as closely correlated with health outcomes as are other measures of body composition. Some sleep-obesity studies have used additional measures of body composition to BMI, finding the sleep-obesity relationship to remain significant.

Again, consistency in findings ameliorates these limitations: the association between sleep and obesity has been consistent when assessing obesity using BMI as a continuous variable, using various cut-offs, and using other measures of body composition. This study will examine waist circumference and skinfold thickness in addition to BMI, to add to the growing body of literature examining relationships between sleep and more direct measures of central adiposity.

Should Obesity Prevention Interventions Target Sleep?

The wealth of epidemiological data documenting a relationship between short sleep duration and obesity, in combination with laboratory studies revealing a potential causal pathway, have led Taheri to propose that "*we should recommend more sleep to prevent obesity*" (2006, manuscript title). However, there are some objections to this proposal, and issues to be addressed.

It has been argued that the relationship between sleep duration and obesity has been overplayed, and even if it is real, the effect size is too small to be significant. Horne (2008) pointed out that for the majority of children, short sleep is unrelated to obesity: that is, most short sleepers are not obese, and most overweight children are not short sleepers. For example, in the ALSPAC cohort (Reilly et al., 2005), 93.2% of children with sleep durations of over 12 hours at age 3 years did not become obese, and 89.7% of those with short sleep durations (<8 hours) also did not become obese. Furthermore, changes are slow, and for a small change in body weight, a large discrepancy in sleep time is needed over a long period of time. In the cohort described by Snell et al. (2007), one more hour of sleep per day at baseline was associated with an increase in BMI of around 0.75 kg/m^2 over 5 years.

In answer to these allegations, Young (2008) described the importance of even small changes to weight at a population level, and the significant improvement to population level health if small changes are made to obesity prevalence. Using the pooled ORs calculated by Cappuccio et al. (2008), Young (2008) calculated that 5-13% of the total proportion of obesity in children could be attributable to short sleep: if extending sleep could reduce obesity prevalence by 5% then this would have important positive implications for public health. Even small shifts in the distribution of BMI in a population can greatly impact on health outcomes on the population level (Bayer et al., 2009). Therefore, whilst it is unclear whether extending sleep could lower weight and treat obesity in individuals, it is likely that if short sleepers increased their sleep duration, then the mean BMI of the population would be reduced, rendering the population of children generally healthier (Young, 2008). The effect of sleep on obesity and BMI should therefore be taken seriously.

Another argument against considering sleep extension as an intervention to prevent or treat obesity is that no intervention or observation studies have shown that extending sleep can lead to weight loss (Marshall et al., 2008). In a study of 173 women aged 50-75 years, there was only limited evidence that changes in sleep duration modified exercise-induced changes in weight (Littman et al., 2007). No intervention or sleep-extension studies have been published with children. However, sufficient sleep has other health benefits in addition to the possibility of preventing obesity (Chapter 1). Given that the weight of evidence suggests that short sleep is associated with obesity, and that the positive health impacts of sufficient sleep extend beyond reducing obesity, the potential benefits of interventions to extend sleep are likely to outweigh the costs. Furthermore, current obesity interventions are not effective (see Chapter 1) and so a potential novel intervention that could have additional positive health impacts is especially important to consider.

The lack of determination of causation or mechanism is a cause of concern. It is not confirmed that short sleep leads to obesity; it is possible that there is reverse causation, or that the association arises due to confounding by other factors. A greater understanding of the mechanisms through which sleep and obesity are related, and the context of the association, would help to determine whether interventions aimed at extending sleep duration to improve obesity prevalence would be successful, and how to make them most effective.

Summary: Should Obesity Prevention Interventions Target Sleep?

There is some suggestion that sleep extension should underpin an intervention to lower the prevalence of obesity in children. There are some concerns with this suggestion; in particular, the mechanisms linking short sleep with obesity are not well understood, and it has not been confirmed that lengthening sleep would result in weight change. A greater understanding of the mechanisms linking short sleep with obesity would help to determine whether, and how, sleep duration could be used effectively to impact obesity. In answer, this study explored potential mechanisms behind the sleep-obesity link, including potential confounding by an independent factor (parenting).

Chapter 2 Summary: Literature Review: The Short Sleep-Obesity Link in Young Children

There is strong and consistent evidence of an association between short sleep duration and obesity in children in different populations around the world. The relationship is longitudinal, linear and dose-responsive, remains significant after controlling for potential confounding factors, and is strongest in young children. There have been calls for obesity prevention interventions to target sleep extension; this is desirable since improving sleep could have additional benefits for children’s health and development in addition to lowering the prevalence of obesity. The mechanisms which link short sleep with obesity are not well understood. In adults, sleep restriction studies have suggested a role of appetite hormones. Potential behavioural mechanisms have not been determined, but may play a role in the relationship; and independent variables may confound the sleep-obesity relationship.

Further to lack of understanding of mechanisms and confirmation of causality, other limitations in the sleep-obesity literature include problems with sleep measures (which have mainly assessed sleep at a single point, masking night-to-night variability in sleep and neglecting daytime naps), lack of consensus of the definition of short sleep (due to lack of understanding of optimal sleep amounts for children at different ages), and problems with obesity measures (which have mainly been based on BMI, which is not a direct indicator of fat mass or central adiposity).

Study Aims

This study addressed limitations in the literature in order to enable more detailed insight into the sleep-obesity link. Whilst the objective of this study was to explore the sleep-obesity link in preschool children, specific topics for exploration were potential behavioural pathways and confounding variables: the following chapter expands on this.

The secondary aims of this study were to expand on and contribute to the literature by following up some suggested improvements, specifically to:

- SECONDARY AIM ONE: Improve on sleep measures used to examine the sleep-obesity relationship, particularly to assess sleep over an extended period (rather than a single night or parent-report of a typical night), assess variability in sleep duration (including week/weekend day and seasonal variation), and include naps in addition to nighttime sleep
- SECONDARY AIM TWO: Examine waist circumference and skinfold thickness in addition to BMI, to add to the growing body of literature examining relationships between sleep and more direct measures of central adiposity
- SECONDARY AIM THREE: Conduct a detailed investigation into sleep in a sample of preschool children, to add to the limited literature regarding children's sleep

The literature which has been reviewed in this chapter is quantitative, and focused on documenting and quantifying the sleep-obesity link. Sleep and obesity are both influenced by an array of family, social and cultural factors which have not been considered in sleep-obesity research to date. The next chapter will explore the ecological context of sleep and obesity and describe a more holistic approach to the study of the sleep-obesity link. In doing so, it will focus on potential behavioural mechanisms linking short sleep with obesity, propose potential confounding variables, and present an evolutionary medicine approach to the study of obesity and sleep.

Chapter 3: Literature Review: Causes and Context of the Childhood Sleep-Obesity Link

This chapter will explore the sleep-obesity link in more depth, specifically the context of the association, and potential causal mechanisms. In order to gain a fuller understanding of the sleep-obesity relationship, it is important to take a holistic approach. Sleep and obesity are both embedded in a complex web of family, social, cultural and environmental factors, which interact with biology to determine the sleep patterns and weight status of individuals. Hormonal mechanisms linking short sleep and obesity have received great attention in the literature; however, examination of biological pathways only encompasses one aspect of children's sleep and obesity.

Behavioural mechanisms have been suggested to explain the sleep-obesity relationship, but this proposal is not yet strongly supported; more detailed exploration of potential behavioural pathways is needed. Furthermore, parenting behaviours and styles are associated with both children's sleep and obesity, but have not yet been considered in the sleep-obesity relationship; exploration of their potential role in the childhood sleep-obesity link is needed. Sleep and obesity both co-vary with ethnicity and SES; understanding any potential role of ethnicity and SES may help to further our understanding of how sleep and obesity are related; and the wider context of social and cultural attitudes and values should also be recognised.

An evolutionary medicine perspective has been applied to explain rising prevalence of obesity in Western societies. An evolutionary perspective may enable novel and deeper insight into the association of obesity with short sleep. It is important to understand the evolutionary context of children's health, including obesity, sleep, and their association.

This chapter will present a) the rationale for considering behavioural mechanisms in the sleep-obesity link, including potential mechanisms to explore, b) the rationale for the potential role of parenting in the sleep-obesity link, c) a discussion of the association of ethnicity and SES with sleep and obesity, and their context in the sleep-obesity link, d) a discussion of the importance of wider social and cultural attitudes and values, and e) an evolutionary medicine approach to obesity, sleep, and the potential to apply this perspective to the sleep-obesity relationship. Finally, the aims of the study will be outlined.

Potential Behavioural Mechanisms Linking Preschool Children's Short Sleep and Obesity

As described in Chapter 2, obesity-promoting behaviours may mediate the link between short sleep and obesity (see Figure 3.1).

Figure 3.1: Obesity-Promoting Behaviours May Mediate the Sleep-Obesity Association

The risk factors for obesity (behaviours and variables which increase an individual's risk of becoming obese) are complex, spanning biological, environmental and socio-economic factors, and beginning as early as gestation. Energy intake and expenditure are recognised to impact upon weight gain; however, their relative contribution to childhood obesity are not determined (Bleich et al., 2010), and an array of factors interact and influence each side of this equation. It is recognised that obesity prevention efforts in children should address dietary and activity behaviours (Brug et al., 2010); before considering the role of obesity-promoting behaviours in the sleep-obesity association, dietary and activity behavioural risk factors will be discussed.

Diet

Dietary behaviours associated with obesity encompass both specific foods consumed and their nutritional content, and wider mealtime practices and eating behaviours.

Regarding foods consumed, the associations between different patterns of food intake and the development of obesity in children are inconclusive and not clear (Rodriguez & Moreno, 2006). However, since obesity occurs due to greater energy intake than energy expenditure, consumption of food high in energy is likely to be obesity promoting, and consumption of food low in energy is likely to be protective. Sweet foods, pre-prepared foods and carbonated drinks are generally high in fat and calorically-dense, therefore likely to promote excessive energy intake; whilst fruit and vegetables are generally low in calories and of low energy density. There are some data to suggest that consumption of these foods is associated with increased and decreased risk of weight gain, accordingly.

Sweet foods and pre-prepared foods (including desserts, chocolate, cakes, biscuits, baked goods, crisps, ready meals and fast food) are high in fat, and fat intake has been associated with increased sum of skinfolds in children as young as 3-7 years-old (Robertson et al., 1999). Specifically, Newby et al. (2003) found that intake of foods designated as “fat foods” (including chips, biscuits, cakes, pies, chocolate and crisps) significantly predicted weight gain in 1379 American preschool children. In older children (aged 10 years), consumption of sweets and “low-quality foods” (which the authors considered to include salty foods, sweets, desserts, fat and oils) were positively associated with overweight status (Nicklas et al., 2003).

Fast food is specifically linked to obesity. Compared to children who did not eat fast food, a study showed that those who ate fast food consumed more total energy, more total fat, more sugars, more sugar-sweetened drinks, and fewer fruits and non-starchy vegetables, leading the authors to suggest that fast food consumption and its associated dietary habits could increase risk for obesity (Bowman et al., 2004).

A review of cross-sectional and prospective cohort studies revealed a positive association between greater intakes of sugar-sweetened beverages, particularly carbonated soft drinks, and weight gain and obesity in children (Malik et al., 2006). In preschoolers, Welsh et al. (2005) found that the consumption of sweet drinks amongst children who were overweight or at risk of overweight was associated with increased risk for obesity. However, no significant associations were found for normal- or underweight children; and O’Connor et al. (2006) found no association between consumption of carbonated drinks and BMI in preschool children; although increased beverage consumption was associated with increased energy intake. Although data linking carbonated drink consumption with risk of obesity in preschool children is inconsistent, their high added sugar content, high caloric value, limited nutrient content and low satiety suggests that these beverages can contribute to weight gain (Newby, 2007).

Direct negative associations of fruit and vegetable consumption with weight gain and obesity in children are scarce, but their consumption has been associated with a more healthful diet in preschoolers (Dennison et al., 1998). Smaller total intakes of fruit and vegetables were found in overweight compared to normal weight school-aged boys, and smaller intakes of fruit were found in overweight school-aged girls (Lin & Morrison, 2002). Inverse associations were found between weekly consumption of vegetables and obesity prevalence in boys, and between weekly consumption of fruit and obesity in girls, all aged 6-7 years old in Mexico (Violante et al., 2005). Furthermore, fruit intake was associated with smaller percent body fat in Croatian children (Baric et al., 2001). Since fruits and vegetables are generally low-energy-dense foods (low in calories, high in water and fibre content), they contribute to satiety and displace more high-energy-foods from the diet (Field et al., 2003); it is therefore reasonable to assume that they are protective against obesity.

Further to possible direct associations between types of foods consumed and obesity in preschool children, dietary intake in preschool children may influence risk of obesity later in life due to the tracking of eating habits over the childhood years and into adulthood (Cooke et al., 2004). Eating habits begin to form early in life, before age 4 years (Nicklas et al., 1991). Preference for healthy food choices was seen to track across the school years (Kelder et al., 1994); and consumption patterns of fruit, vegetables, sugar-containing drinks and sugary foods were found to track from age 14 to age 21 years (Lien et al., 2001). The amount of fruit and vegetables that preschool children are exposed to is important (Nicklas et al., 2001a): young children have been found to prefer vegetables frequently served in their homes or at their day care centres (Phillips & Kolasa, 1980). Among adults, habits such as "eating lots of fruits and vegetables" during childhood were a significant positive predictor of their current fruit and vegetable intake (Krebs-Smith et al., 1995). Moreover, Klesges et al. (1995) found that healthy dietary intake patterns can decrease accelerated weight gain and obesity, even in preschool children.

In sum, consumption of fruit and vegetables is likely to be obesity-protective, whilst consumption of carbonated drinks, sweets and pre-prepared foods (including cakes, sweets, chocolate, desserts, ready meals, crisps, baked foods and fast food) are likely to promote obesity. This is due to their nutritional content (including energy density), and the tracking of dietary patterns into later life.

Eating Patterns and Mealtime Practices

Eating patterns that contribute to obesity include frequently eating meals at restaurants, and increased portion sizes, due to the associated increased energy consumption (Nicklas et al., 2001b). Further obesity-promoting eating patterns include distribution of eating throughout the day, specifically eating frequency and meal-skipping (Nicklas et al., 2001b; Ma et al., 2003), and not regularly eating meals as a family.

Regarding meal-skipping, a review of 25 studies with children and adolescents concluded that children who consistently ate breakfast had superior nutritional profiles compared to those who skipped breakfast, and were less likely to be overweight (Rampersaud et al., 2005). A large (n=1549) cross-sectional study of Canadian preschoolers found that 10% ate breakfast on fewer than 7 days per week: these children had lower diet qualities and concentrated energy intakes in the afternoon and evening, through energy- and carbohydrate-dense snacks (Dubois et al., 2009). The authors concluded that daily breakfast consumption was associated with healthy body weight, probably due to a more even distribution of energy intake across meals throughout the day.

Indeed, daily distribution of food intake may be important for obesity risk. A study of 339 French children aged 7-12 years compared children with different weight statuses. Overweight and obese children ate less at breakfast and more at dinner compared to their leaner peers (Bellisle et al., 1988). In 2870 older Norwegian children (mean age 15 years), risk for overweight increased as the number of meals decreased; eating 4 meals per day was significantly negatively related to being overweight (Vik et al., 2010).

Similarly, in adults, a lower obesity risk has been observed among those with larger numbers of eating episodes per day (Ma et al., 2003). Evening food consumption may be particularly important for obesity risk. Further to concentrated energy intake in the evening rather than even distribution throughout the day, consumption of late-evening meals with carbohydrate-rich foods may be related to obesity, through its effect on hormonal regulation of energy and lipid metabolism (Ma et al., 2003).

Eating meals as a family is a positive mealtime practice. Companionship during meals has been associated with increased intake of basic food groups in preschool children (Stanek et al., 1990). A study of 8550 American preschool children found prevalence of obesity to be reduced in children regularly eating dinner as a family (Anderson & Whitaker, 2010, see below). In a longitudinal study of 11,400 American preschool children, Miller (in press) reported more breakfasts eaten per week with their families to be associated with decreases in the rate of BMI growth over time; contrastingly, eating more breakfasts and lunches at school was associated with faster rates of BMI growth. The reason for family meals being associated with decreased risk of obesity is unclear. Perhaps the foods served at family meals are less likely to be pre-prepared, and more likely to be obesity-protecting (Cooke et al., 2004); also, there is evidence that observing parents and siblings eating foods encourages children to consume the same foods (Cullen et al., 2001). Further to simply eating meals as a family, the number of people present plays a role in the link between eating as a family and dietary outcomes, as does their relationships and the content of verbal and nonverbal interactions (Anderson & Whitaker, 2010), and whether the TV is on during meals (Fitzpatrick et al., 2007).

Activity

In addition to dietary behaviours, research has focused on activity determinants of obesity. Both reduced physical activity and increased sedentary activity are risk factors for obesity (Epstein et al., 2000; Whitaker, 2003).

Studies with preschool-aged children have demonstrated physical activity to protect against accelerated weight gain, and to be inversely associated with change in body fatness (Klesges et al., 1995; Moore et al., 1995). Active play may be important for young children: in the large prospective cohort reported by Miller (in press), greater minutes of free time for activity in preschoolers (during nursery school hours) was associated with decreases in the rate of BMI growth over time.

Sedentary activity, in particular TV viewing, is predictive of obesity in children. Watching more than 8 hours of weekly TV at age 3 years was a risk factor for obesity at age 7 years in the ALSPAC cohort (Reilly et al., 2005). Proctor et al. (2003) followed 106 children from preschool age until early adolescence, and found that children who watched the most TV during childhood had the greatest increase in body fat over time. Danner (2008) similarly found that in an American cohort of 7,334 children, hours of TV viewing at preschool age was significantly positively associated with the acceleration of BMI growth over the following years. In a tri-ethnic cohort of 3-4 year-old children, TV viewing became positively associated with BMI over 3 years (Jago et al., 2005).

Further to the amount of TV viewing, having a TV in the bedroom is a particular risk factor for childhood overweight, independent of physical activity (Adachi-Mejia et al., 2007). In an American cohort of 2761 preschool children (Dennison et al., 2002), odds of obesity increased for each additional hour of TV viewed per day, with children with a TV in their bedroom being more likely to be overweight.

The association between TV viewing and obesity could be due to the correlation of TV viewing with obesity-promoting dietary habits, and TV viewing replacing more physical activities. Indeed, TV viewing is positively associated with calorie intake in children, mediated by increased consumption of calorie-dense, low-nutrient foods which are advertised on TV (Wiecha et al., 2006). Additionally, Jackson et al. (2009) found that preschool children who watched more TV were less physically active.

Diet and Activity in Sleep-Obesity Research

As described in Chapter 2, some of the studies into the sleep-obesity relationship in preschool children have attempted to control for dietary and activity determinants of obesity. Dietary risk factors which have been adjusted for include fruit and vegetable intake (Shi et al., 2010) and frequency of consuming breakfast (Chaput et al., 2006, 2007). The ALSPAC study found the relationship between children's sleep at age 30 months and obesity status at age 7 years to be independent of energy intake at age 3 years (Reilly et al., 2005). Regarding activity, some studies have attempted to control for physical activity or sedentary activity, and some both (see Chapter 2). For example, Sekine et al. (2002b) controlled for number of hours of outdoor playing time, and Chaput et al. (2006, 2007) adjusted for frequency of practicing sports activities outside of school, and duration of daily TV viewing and other sedentary activities (computer use, videogames). In their prospective cohort, Taveras et al. (2008) controlled for daily TV viewing and daily participation in active play, and found sleep duration in infancy to remain significantly correlated with risk of childhood overweight.

Although research into the sleep-obesity link has controlled for dietary and activity variables, and found the relationship to remain significant, there is inconsistency in the dietary and activity variables adjusted for in statistical models, which reflects the lack of consensus regarding the best measures to use. Mediation of the link by obesity-promoting dietary or activity behaviours is plausible, especially since there is some evidence documenting an association of sleep duration with such risk factors.

Stamatakis & Brownson (2008) demonstrated short sleep duration in American adults to be associated with reduced physical activity, low fruit and vegetable consumption, high-fat diet, and frequent consumption of fast food, all of which are risk factors for obesity. These associations remained significant when non-obese adults were analysed separately, supporting the hypothesis that short sleep duration in normal weight people can contribute to weight gain and subsequent obesity. In Taiwanese adolescents, inadequate sleep (defined as not regularly achieving 6-8 hours of sleep per night) was associated with lower physical activity and worse dietary habits (Chen et al., 2006). Furthermore, in a study of sleep and obesity in children and adolescents, Olds et al. (2010) conducted a subgroup analysis of the obese group, comparing those who did and did not obtain recommended sleep amounts. They found differences in total screen time and TV time, which they concluded confirms that other factors are interacting with the relationship between weight status and sleep.

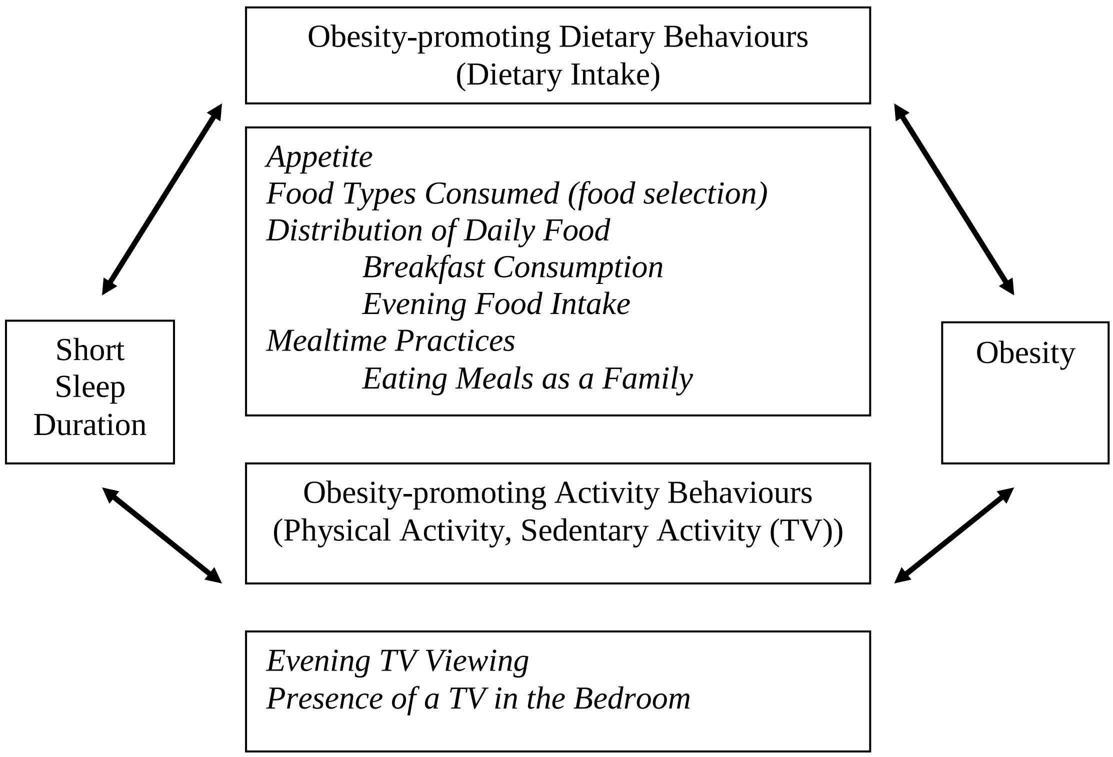
These results support a role of obesity-promoting behaviours as mediators of the sleep-obesity link. More detailed investigation of the relationships of activity and dietary behaviours with sleep and obesity may shed light on potential behavioural mechanisms and causal pathways in the sleep-obesity association. Indeed, there are aspects of diet and activity which are associated with obesity and/or sleep which have not yet been included in sleep-obesity research, and which should be considered.

Laboratory studies of sleep restriction suggest that short sleep duration increases appetite and alters food selection in adults (see Chapter 2); therefore it may be helpful to examine appetite and the specific types of foods consumed in relation to the sleep-obesity link in young children, particularly the obesity-promoting and -protecting food types identified above. (Note that food selection and food types consumed depend on children's access to food, therefore parenting (food provision and children's access to food) may be involved; see below). Distribution of food intake throughout the day is associated with obesity, and may be associated with sleep also. For example, breakfast-skipping is associated with increased risk of obesity, and sleep restriction is associated with appetite upon waking, which could impact on breakfast habits. Additionally, evening food consumption and late-evening meals may contribute to obesity, and are also associated with sleep. For example, late, high calorie dinners, and their associated thermic effects and temperature increase, can delay sleep onset and shorten sleep duration (Locard et al., 1992). The types and timing of foods eaten in the evening can induce sleep, for example foods high in tryptophan (an amino acid) aid sleep if given around 45 minutes to an hour before bedtime; and foods high in carbohydrates and calcium and medium to low in protein are recommended to aid sleep (Galland & Mitchell, 2010). Therefore, evening food consumption may contribute to both sleep and obesity risk, thereby confounding the sleep-obesity relationship.

Regarding activity, sleep-obesity studies have adjusted for measures of daily TV viewing. However, the presence of a TV in the bedroom is strongly associated with obesity and also contributes to sleep disruption (see below): the presence of a TV in the bedroom should therefore be examined in more depth as a potential mediator or confounder. Furthermore, TV viewing may displace sleep time, since the majority of children's TV viewing is thought to occur near bedtime; and evening TV viewing can lead to sleep disruption (see below). Therefore, evening TV viewing in particular may play a role in the sleep-obesity link, and has been neglected to date.

As a result of reviewing literature regarding dietary and activity obesity risk factors and their potential association with sleep, Figure 3.2 depicts how dietary and activity factors may contribute to the sleep-obesity link. The bi-directionality of arrows indicates that causality in either direction is possible, or causality is not known; these obesity-promoting factors could therefore either mediate or confound the sleep-obesity relationship. Italic font indicates factors which have not as yet been considered in sleep-obesity research, but which may play a role (as described in the text).

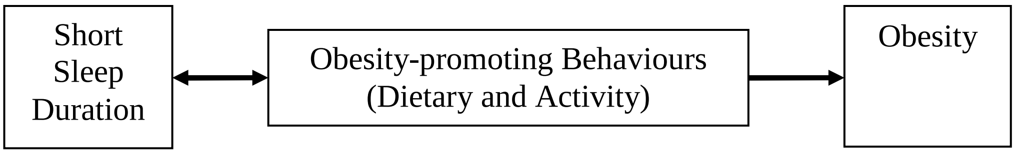
Figure 3.2: Potential Role of Obesity-Promoting Dietary and Activity Behaviours in the Sleep-Obesity Link



Summary: Potential Behavioural Mechanisms Linking Preschool Children's Short Sleep and Obesity

There is an array of dietary and activity behaviours which contribute to obesity risk, some of which have been associated with sleep and could be implicated in the sleep-obesity relationship. The contribution of dietary and activity behaviours to the sleep-obesity link has not been determined, and there are some factors which have not been included in research to date. This thesis will explore the potential role of dietary and activity behaviours in the sleep-obesity association, as shown in Figure 3.3; particularly the types of foods consumed and their daily distribution; and bedroom TVs and evening TV viewing.

Figure 3.3: Model A for Exploration: Potential Behavioural Mechanisms Linking Children's Short Sleep and Obesity



Specific dietary and activity behaviours have not been conclusively linked to both sleep and obesity. An exploratory study, which investigates different components in order to generate appropriate hypotheses, is needed.

The Potential Role of Parenting in the Sleep-Obesity Link in Young Children

Parenting practices and behaviours are important for both sleep and obesity; hence it is possible that parenting confounds the sleep-obesity link. For preschool children, parenting is particularly influential. Sleep-obesity research has not included an examination of parenting styles and behaviours; examining parenting in relation to the sleep-obesity link may help to gain a more comprehensive understanding.

Parenting Practices and Children's Sleep

There is strong empirical evidence that behavioural factors (learned behaviours) are involved in children's sleep, including the onset or prevention of sleep problems (Wiggs, 2009). Behavioural aspects are shaped by the social and cultural environment (Wiggs, 2007); for young children, parents' attitudes and practices are particularly influential.

There is a recognised set of behaviours (referred to as "sleep hygiene") which promote good sleep quality and efficiency, in particular quick sleep onset at the beginning of the sleep period, and consolidated, undisturbed sleep throughout the night. They are modifiable parent (or child) practices, which involve sleep environment, sleep routine and daytime activities (Mindell et al., 2009a). Commonly recommended sleep hygiene practices include a consistent sleep schedule, with regular (appropriately early) bedtime, wake up time, and nap schedules for young children. Also included is a regular bedtime routine, involving a consistent set of calming, relaxing activities (such as reading, talking to parents), ending in children falling asleep independently in their own bed. TVs and caffeine are recommended to be avoided in the evening. The aim is for parents and children to practice sleep hygiene habits routinely, so that they become habit; educating parents in such practices is important in helping children to sleep (Galland & Mitchell, 2010).

A 2004 poll of parents of 1473 American children aged 0-10 years confirmed that poor sleep hygiene was associated with shorter sleep in all age groups (Mindell et al., 2009a). In particular, a late bedtime, lack of a bedtime routine, having a parent present when falling asleep, and having a TV in the bedroom were associated with shorter sleep in preschool-aged children. The association of these parent-modifiable behaviours with sleep duration supports the association of parenting with children’s sleep.

Bedtime

The use of regular bedtimes is associated with quicker sleep onset and consolidated sleep through the night (Hale et al., 2009). The reason is partly biological: the natural period of the human circadian clock is 24.18 hours (Czeisler et al., 1999); in order to entrain the circadian rhythm to the 24-hour day, the biological clock has to be “reset” by an average of 0.2 hours per day (Gronfier et al., 2007). Regular sleep schedules, particularly bedtimes, are required to entrain the circadian clock to the 24-hour cycle.

Further to being regular, appropriately early timing of bedtime ensures adequate sleep opportunity for children; indeed, late bedtimes are a significant contributor to short nighttime sleep duration. Iglowstein et al. (2003) assigned the decrease in sleep duration across recent decades to increasingly later bedtimes, and in Mindell et al.’s (2009a) American poll, a late bedtime was the strongest predictor of short sleep duration in children. Olds et al. (2010) found weight status to correlate with sleep duration and with bedtime, but not with wake up time; the authors agreed that short sleep duration is mainly attributable to late bedtime rather than early wake up time, and that the difference in weight status was mainly due to differences in bedtime. An appropriately early, regular bedtime may therefore be a particular modifiable behaviour which could contribute to longer sleep and associated health outcomes in children.

Bedtime Routine

The use of a consistent bedtime routine helps children learn to associate the pre-bedtime period with the upcoming sleep period, therefore cueing them for sleep (Cohen, 1999, cited in Hale et al., 2009). The use of a regular bedtime routine has consistently been associated with sleep outcomes for children; for example, in Sadeh et al.'s (2009) study of 5006 parents of US and Canadian children aged 0-3 years, regularity of bedtime ritual or routine was positively associated with nighttime sleep duration and negatively associated with number of night wakings. Similarly, Mindell et al. (2009b) found that the presence of a regular bedtime routine in children aged 18-36 months was associated with longer sleep continuity, reduced number and duration of night wakings, and reduced maternal perception of children's sleep problems. Furthermore, Fiese et al. (2007) reported that in children with asthma, disruptions in bedtime routine were associated with increased odds that children would wake in the middle of the night, leading the authors to suggest that in addition to general routines, daily fluctuations in routines can affect children's sleep.

The components of a bedtime routine are important. Components which are effective at promoting sleep include quiet and relaxing activities (Hale et al., 2009; Mindell et al., 2009b) such as reading, having a bath, singing and talking to parents (Beltramini & Hertzig, 1983, cited in Hale et al., 2009). In the American poll presented by Mindell et al. (2009a), 58% of preschoolers had reading included in their bedtime routine; and in a sample of white American children (Milan et al. 2007), 67% were told a story at bedtime. Children in literate families, whose parents read to them, have been documented to have longer sleep compared to those in illiterate families (Jones et al., 2003, cited in Davis et al., 2004): rather than reading having a direct association with sleep, Mindell et al. (2009a) propose that reading at bedtime is associated with structure and the prioritisation of children's sleep within the family, which is positively associated with sleep.

TV

Whilst reading is a positive component of a bedtime routine, TV viewing can disrupt sleep. In a study of 1099 American children aged 4-10 years, disturbed sleep was more likely in children who watched more TV and who had a TV in their bedroom (Owens et al., 1999b). Gupta et al. (1994) similarly found that in Indian children aged 3-10 years, sleep patterns were disturbed by TV viewing.

Watching TV at night in particular is a significant contributor to reduced nighttime sleep duration and sleep disruption in children; for example, TV viewing at bedtime and the presence of a TV in the bedroom were associated with shorter and more disturbed sleep in the study by Owens et al. (1999b). TV viewing may disrupt sleep by inhibiting relaxation (Thompson & Christakis 2005), or by light from the TV affecting circadian rhythms and sleep onset (Davis et al., 2004). There is emerging evidence of a mechanistic link between screen exposure and sleep disturbance: melatonin (a sleep-promoting hormone) is suppressed by bright light, particularly blue light, which is emitted by TV screens; therefore, exposure to screens in the evening may increase alertness, decrease ability to initiate sleep, and disrupt sleep (Olds et al., 2010). Furthermore, evening TV viewing replaces sleep time, resulting in reduced sleep opportunity: a UK report suggested that most TV viewing in children occurs at or near bedtime (cited in Taheri, 2006). Hence as described above, evening TV viewing and the presence of a TV in the bedroom may contribute to the sleep-obesity link.

Although TV viewing leading up to bedtime and having a TV in the bedroom are disruptive for sleep, bedroom TVs are prevalent in preschool children in Western society: in two separate American studies, almost 40%, and 30%, respectively, of preschool children were reported to have a TV in their bedroom (Dennison et al., 2002; Mindell et al., 2009a).

Sleep Location

Sleep location is a significant contributor to children’s sleep outcomes. Longer and more consolidated sleep is aided by sleeping in a bed in a comfortable, quiet, dark bedroom (see below). In addition to the physical environment of the bedroom, room-sharing and bed-sharing are particularly important for sleep outcomes: in a large cohort of US and Canadian children aged 0-36 months, Sadeh et al. (2009) found that sleeping in a separate room was the strongest predictor of nighttime sleep duration.

Regarding room-sharing, there is relatively little scope for parental modification in behaviour, as there may be constraints on space and resources. However, the ways in which parents interact with their children at bedtime and throughout the night are more amenable to modification, and are associated with children's sleep. Parental presence until sleep onset was the factor most strongly associated with lack of sleep consolidation in children almost 3-years-old (Touchette et al., 2005); and bringing a child into the parents' bed was associated with increased night wakings and shorter consolidated sleep episodes in the sample studied by Sadeh et al. (2009). Lack of sleep consolidation is negatively perceived in the literature; this was considered a "worse" sleep outcome by both Touchette et al. and Sadeh et al.. This, however, is an assumption, and there is as yet no data linking lack of sleep consolidation with negative biological consequences; although in a window of restricted sleep opportunity, it may result in inadequate sleep duration.

Parents' attitudes towards children sleeping in their own room or their own bed are influenced by cultural values and expectations, and vary cross-culturally (see below). In some cultures, room-sharing and particularly bed-sharing are positively perceived; comparatively, the above studies positively referred to independent sleeping, reflecting that in Western societies, independent sleep is generally perceived positively. Sadeh et al. (2009) reported that 67% of US and Canadian children aged 24-36 months slept in their own room, whilst the frequency of sleeping in their parents' bed was 15%. Milan et al. (2007) reported that 47% of white American preschool children slept in a room of their own, but there were differences with other ethnicities.

Behaviour Modifications

The sleep practices described above (regular and appropriately early bedtimes, bedtime routines, TV viewing, sleep location) are modifiable and, for preschool children, they are modifiable by parents. As such, they demonstrate that parents are able to influence their childrens' sleep through bedtime and nighttime behaviours.

Further evidence for a direct affect of parenting on children's sleep comes from studies which demonstrate that for children whose sleep is considered disordered, changing parental behaviours can improve sleep (Adams & Rickert, 1989). In addition to managing childhood sleeplessness, behavioural interventions can be used preventively to discourage sleeplessness in children and infants (Wiggs, 2009). Educating parents about how their behaviours at bedtime affects on their children's sleep, and how to modify their behaviours, has been successful for young children (Kuhn & Elliott, 2003; Mindell et al., 2006; Ramchandani et al., 2000; Sadeh, 2005), and has helped to establish better sleeping patterns in newborns (Wolfson et al., 1992).

Parenting Styles and Children's Sleep

Further to specific parental bedtime behaviours, direct associations between parenting styles and children's sleep have been documented. Specifically, lack of limit-setting and consistency in parenting was correlated with disturbed child sleep in a sample studied by Owens-Stively et al. (1997). In children without diagnosed sleep problems, parental laxness (considered to be a parenting style characterized by inconsistency, lack of limit setting, and inadequate enforcement of rules) was associated with more disturbed sleep.

Another study of school children found that parenting styles associated with bedtime 'vigilance' (for example checking that children are in bed, turning the bedroom lights off) were associated with longer time in bed (Meijer et al., 2001). Spilsbury et al. (2005) also found parenting styles to be associated with sleep in children, with styles encouraging social maturity being linked to improved sleep patterns (longer sleep duration and decreased likelihood of late bedtimes).

In line with the positive association of parental regulation with children's sleep, Johnson & McMahon (2008) demonstrated that low 'parental hardiness' predicted sleep problems in preschool children. They posited that 'hardy' parents value limit-setting and promote autonomy during routines and throughout the night, even when children protest. Less 'hardy' parents, they proposed, fail to maintain limits and regulations in order to avoid stress, resulting in difficulty in children initiating and maintaining sleep.

Parenting Practices and Children's Risk of Obesity

Associations of dietary and activity behaviours with risk of obesity for preschool children have been described above. These behaviour patterns are under parental influence (parents can influence what children eat, where and with whom; and what activities children undertake and when): parents are therefore implicated in children's risk of obesity. Indeed, there is direct evidence of a link of parenting with children's diet, and with children's risk of obesity.

Parenting and Children's Food Intake

Parents can influence their preschool children's dietary practices in a number of ways: controlling availability and accessibility of foods, structuring meals, food socialization practices, and food-related parenting style (Nicklas et al., 2001a, 2001b).

There is some evidence of a direct relationship between parenting behaviours and children's food intake, which is associated with the risk of obesity. However, evidence is inconclusive and contradictory. Some studies have found parental control to be negatively associated with child diet. In a review of the impact of parental control, Birch (1999) concluded that restriction of snack foods raises child awareness and makes these foods more desirable; children as young as 3-years-old have been demonstrated to consequently choose more of the restricted foods when given the opportunity (Fisher & Birch, 1999).

In contrast, other studies have found parental control to improve diet and even reduce weight in children. Wardle et al. (2002) found that preschool children at risk for becoming obese had parents who showed less control, in comparison to normal-weight children, leading the authors to conclude that lack of control of diet might contribute to differences in child weight. Parental restriction of their daughters' diets predicted daughters' eating and energy intake, and relative weight in 5-year-old girls (Birch & Fisher, 2000). Brown et al. (2008) demonstrated parental control of diet to be correlated with reduced intake of unhealthy snacks and greater intake of fruit and vegetables in preschool children. Brown et al. found that the type of control used by parents was important: whilst covert control had positive associations (fewer unhealthy snacks and more fruit and vegetables), overt control and pressure to eat had negative associations with diet.

Pressure to eat has a complex interaction with child growth, probably because it inhibits child response to their own hunger and satiety cues and encourages them to overeat (Carper et al., 2000; Orrell-Valente et al., 2007). Parental pressure to eat has been correlated with children eating more unhealthy snacks and fewer fruit and vegetables (Brown et al., 2008), and encouragement of food intake has been linked to restricted growth in children in the first year of life (Wright et al., 2006).

Parenting Style and Children's Risk of Obesity

Further to an association of parenting behaviours with diet, there is evidence of a direct link between parenting style and obesity in children. The four classic, widely used parenting style classifications are those originally described by Baumrind (1971) and modified by Maccoby & Martin (1983) (see Table 3.1), and they combine levels of warmth and control. The use of parental authority, whether it should be used, and when and how, is subject to debate (Buri, 1991); however, authoritative parenting is commonly considered the ideal style. It is characterised by high levels of warmth and control (for example limit-setting and monitoring), and has been associated with improved child outcomes, including greater self-esteem, social and cognitive skills, and fewer emotional and behavioural problems (Wake et al., 2007).

Table 3.1: Parenting Styles

	High Control	*Low Control*
High Warmth	Authoritative	Permissive
Low Warmth	Authoritarian	Disengaged/ Neglectful

A sample of 4934 Australian preschool children and their parents was assessed for BMI and parenting style (Wake et al., 2007): low paternal parenting control was strongly associated with preschooler overweight and obesity, even after controlling for a range of predictors of child BMI. The authors concluded that paternal parenting involving high control and warmth may help to protect against preschooler overweight and obesity.

Although the study did not find maternal parenting style to be associated with child overweight, a longitudinal study of 872 American children did find an effect of maternal parenting. Rhee et al. (2006) found that maternal parenting style at child age 3 years was associated with child weight status 2 years later: authoritarian parenting was associated with the greatest risk of overweight; children of permissive and disengaged mothers were also at increased risk for overweight in comparison to authoritative mothers.

Parenting style regarding diet is associated with overall parenting style: Hughes et al. (2005) demonstrated that authoritarian feeding styles were related to overall authoritarian parenting styles, and authoritative feeding styles were associated with generally higher parental control, structure, support and involvement. Furthermore, indulgent, permissive feeding style in parents was associated with the highest child BMIs compared to other feeding styles.

A cross-sectional study of American preschoolers and their parents examined relationships between parenting practices and child BMI (Shea et al., 2010). Greater BMI was predicted by parents feeling responsible for what their children ate; lower BMI was predicted when children were engaged in organized sports and activities. The authors concluded that BMI is associated with parental practices related to feeding and organised sports or activities, and also parental perceptions and concerns.

Household Interactions and Children's Risk of Obesity

Further to parenting in particular, overall family functioning and family interactions have been implicated in childhood obesity. For example, a study of 30 obese children and their families concluded that they differed from families in a normative sample by interacting in a more negative way (Banis et al., 1988). Obese families have been found to perceive their homes as less cohesive, more conflictual, and less organised compared to normal-weight families (Beck & Terry, 1988). Garasky et al. (2009) found that for young children (5-12 years-old), lack of cognitive stimulation and emotional support was linked to overweight and obesity; and Zeller et al. (2007) found that mothers of obese children reported higher levels of family conflict.

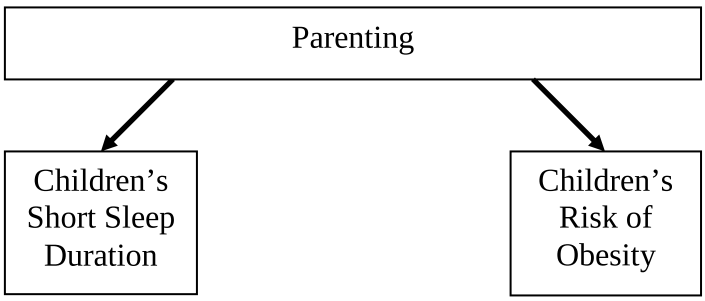
A review of environmental factors, stressors and childhood obesity found that psychosocial stressors in the household and individual psychosocial stressors are associated with obesity in children, with family stressors including low self-esteem, financial strain, low family closeness, maternal depression, neglect, and maternal distress (Gundersen et al., 2010). These stressors are particularly prevalent for low-income children, who experience a greater prevalence of obesity (see below).

Recently, obesity risk in American preschool children has been linked to household routines. Anderson & Whitaker (2010) conducted a cross-sectional study of a nationally representative sample of 8550 4-year-old children, focusing on obesity in relation to 3 household routines: regularly eating the evening meal as a family, obtaining adequate nighttime sleep (which they defined as 10.5 hours or more), and having limited screen-viewing time on week days (2 hours or less). Children exposed to all 3 routines had a 40% lower prevalence of obesity compared to those exposed to none. There was a cumulative effect: after adjusting for covariates, the odds of obesity associated with exposure to all 3, any 2, or only 1 routine (compared to none) were 0.63 (95% CI 0.46-0.87), 0.64 (0.47-0.85), and 0.84 (0.63-1.12) respectively. Their study highlights the association of the household and family environment with children's risk of obesity.

Parenting and the Sleep-Obesity Link

This section has highlighted how parents' behaviours and styles of parenting (including household interactions) are associated with both children's sleep and obesity risk. Parenting may therefore confound the sleep-obesity association (see Figure 3.4).

Figure 3.4: Potential Confounding Role of Parenting in the Sleep-Obesity Link

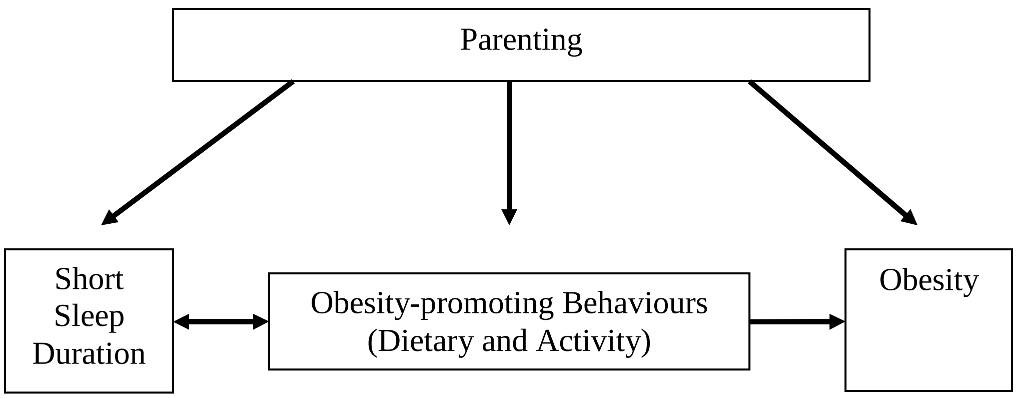


It is important to consider what role, if any, parenting plays in the sleep-obesity relationship, since this will enable further understanding of the mechanisms linking sleep and obesity, and may reveal that the association is spurious rather than causal. Sleep-obesity research to date has not included an examination of parenting styles, attitudes and practices. In particular, the importance of bedtime routines and other household routines for sleep and obesity is widely recognised, but the presence or absence of these behaviours has not been considered in sleep-obesity research.

Summary: The Potential Role of Parenting in the Sleep-Obesity Link in Young Children

There is evidence that parenting behaviours and styles are associated with children's sleep, and also with children's obesity risk (directly, and via obesity-promoting behaviours). Therefore, parenting may confound the sleep-obesity relationship. This thesis will explore the potential role of parenting in the sleep-obesity link; hence it is added to the previous model (Model A) as shown in Figure 3.5, Model B.

Figure 3.5: Model B for Exploration: Potential Role of Parenting in the Childhood Sleep-Obesity Link



Different aspects of parenting and parenting behaviours have been assessed in different studies, and there are no hypotheses regarding specific parenting practices and styles; therefore this model is not prescriptive regarding the parenting component. An exploratory study, which incorporates qualitative methods to explore parenting in order to generate appropriate hypotheses, is therefore needed.

Ethnicity and Socio-Demographic Characteristics in the Childhood Sleep-Obesity Link

There is evidence that ethnicity and socio-demographic characteristics are associated with both sleep and obesity risk in children. Examining these relationships may enable wider understanding of the sleep-obesity association, and potentially reveal a role of ethnicity and/or socio-demographic characteristics in the sleep-obesity relationship.

Ethnicity and Children's Sleep

As described in Chapter 2, there are documented cross-cultural differences in children's sleep patterns, including amount of sleep and distribution throughout the day. In addition to a direct association of ethnicity with sleep duration, there are cross-cultural differences in sleep practices, including where children sleep, how they are put to bed, and the level of concern mothers have about their child's sleep (Milan et al., 2007). Specifically, after controlling for environmental factors, Milan et al. (2007) found that white American children most commonly slept in their own bedroom, whilst African American and Latino children more commonly shared bedrooms; bedtime routines were more common for white children, as was reading in particular. This was mirrored in a study of 3217 American preschool children, which found that white children were 30-50% more likely to have bedtime routines compared to Black and Hispanic children, in particular interactive routines including reading; they also had earlier and more regular bedtimes (Hale et al., 2009).

Ethnicity and Children's Obesity Risk

Prevalence of obesity varies between ethnic groups. In Britain, white children experience amongst the lowest risk of obesity (NOO, 2011); whilst national surveys demonstrate that some ethnic minority groups, particularly from South Asia, have greater risk of obesity compared to white British children (Rennie & Jebb, 2005). American children from ethnic minority groups are also at a higher risk for becoming obese compared to Caucasian children (Zhang & Wang, 2004).

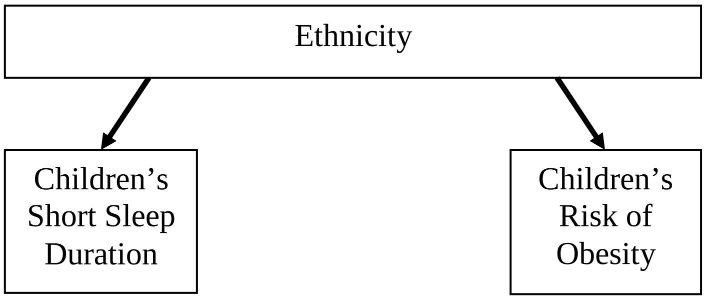
Dietary and activity obesity-promoting behaviours vary with ethnicity. A systematic review found significant differences in nutritional composition of children's diets by ethnicity: compared with white Europeans, children from South Asian ethnic groups, particularly Bangladeshi children, reported higher mean total energy intake (Rees et al., 2009). In British children aged 2-6 years, white children ate more fruit compared to children from other ethnic groups, but there was no significant difference in vegetable consumption (Cooke et al., 2004). On the other hand, in British 4-year-old children, the "junk" diet identified in the ALSPAC cohort was significantly more prevalent in white compared to non-white children, and non-white children scored higher for the "health-conscious" dietary pattern (Northstone et al., 2005).

Correlations of physical activity levels with ethnicity are inconsistent. In primary school children in the UK (aged 9-10 years), South Asian children had lower objectively measured physical activity levels compared to European white, and black African-Caribbean children (Owen et al., 2009). Contrastingly, Pate et al. (2004) reported black children participating in more moderate-to-vigorous physical activity compared to white children in a sample of American preschool children. In a review of correlates of physical activity in children, Sallis et al. (2000**)** found only one study to report ethnic differences in activity, with most studies showing ethnic minority children to be as active as white children. Ethnic variation in TV viewing has been documented in American preschool children, with white children watching less TV compared to Black and Hispanic children (Dennison et al., 2002).

Ethnicity in the Childhood Sleep-Obesity Link

The sleep-obesity link has been observed in different countries and ethnic groups, suggesting that it is consistent cross-culturally and that short sleep and obesity are related independently of ethnicity (see Chapter 2). However, there is some evidence that sleep and obesity rates vary with ethnicity: perhaps ethnicity can explain some of the sleep-obesity link, for example by confounding the relationship (see Figure 3.6). Since the association of ethnicity with sleep, obesity prevalence and obesity risk factors is inconsistent and not determined, no specific hypotheses regarding the role of ethnicity can be proposed.

Figure 3.6: Potential Confounding Role of Ethnicity in the Sleep-Obesity Relationship



The causes of ethnic variation in sleep duration and obesity risk may be biological, environmental or socio-economic. Body composition varies with ethnicity, and it is undetermined whether there is a biological difference in sleep need. Alternatively, different attitudes and values across cultures contribute to sleep duration and obesity risk. Although sleep-obesity studies have examined the link in different ethnic groups, ethnicity is a crude measure which does not explore the cultural context of the sleep-obesity link, for example how cross-cultural differences in attitudes and values contribute to the relationship. This is discussed below.

Socio-Demographic Characteristics and Children's Sleep

Children's sleep has been correlated with socio-demographic characteristics, although the results are inconsistent. Commonly used demographic characteristics and indicators of SES in research (including sleep-obesity research) are parents' education level and income, household crowding, and family composition. A study of British primary school children identified socio-cultural factors which were risk factors for problematic sleep (Rona et al., 1998): maternal education level and paternal social class were inversely associated with disturbed child sleep, whilst children whose birth order was fourth or later slept more poorly. Overcrowding did not have a clear effect: children who lived in houses with an average of 1.5 people per room were most likely to have disturbed sleep, compared to fewer or more people per room. A study of young American children also identified more problematic sleep in children of lower SES as measured by zipcode and household income (Crabtree et al., 2005).

Contrary to these findings, an American National Survey of Children's Health found that inadequate sleep was more likely in children whose parents achieved greater than high school education and whose income was higher (Smaldone et al., 2007). No difference was found in sleep between children with two parents versus a single mother, or with number of children in the household.

In contrast to both of these sets of findings, in their analysis of an American national poll of 1473 parents, Mindell et al. (2009a) found that sleep in preschool children was not associated with household income, parental employment and education, or marital status. In young Israeli children, Scher et al. (1995) also found no affect of SES on sleep; however, there were marginal correlations between sleep and demographic variables, including later sleep start time in first-born children, and earlier wakings in children of younger mothers.

Further indication of a role of SES in children's sleep comes from an examination of the association of child and family social and demographic characteristics with bedtime routines in 3217 3-year-old American children (Hale et al., 2009). In addition to ethnic variation (described above), they found that bedtime behaviours were shaped by caregiver (age, education level) and household characteristics (poverty level, number of adults in the household, household crowding). In particular, less advantaged parents were less likely to have regular bedtimes and bedtime routines for their children, particularly interactive routines such as reading. The authors hypothesised that this may be due to increased stress in these households, lack of structure and routines in general, or lack of awareness of the positive effects of bedtime routines.

Hence associations of sleep with SES are conflicting and inconsistent. Comparisons across studies are limited by differences in definitions (Smaldone et al., 2007), and more detailed examination of sleep patterns in relation to SES is needed. Hale et al.'s conclusions suggest SES variation in parents' attitudes and values. Further parental variables which may cause SES to be associated with sleep include education level and sleep knowledge, work status and schedules, and competing priorities for time (Owens, 2004). Mental health variables, including family stress and maternal depression, are further parental variables which are linked with children's sleep (Gallagher et al., 1995; Hiscock & Wake, 2001). Further possible causes for SES variation in sleep include affects of family composition (relationships, number and ages of siblings) (Owens, 2004), and aspects of the physical environment. Poorer sleep is associated with excessive noise or light (Kahn et al., 1989), uncomfortable sleep surfaces and low bedroom temperatures (Spilsbury et al., 2005), and with household crowding and limited space (Owens, 2004). These physical factors are associated with poorer SES and ethnic minorities; physical environment may therefore partly explain the association of SES and ethnicity with sleep in children.

Socio-Demographic Characteristics and Children's Obesity Risk

There is more consistent evidence documenting an effect of SES on childrens' risk of obesity. In the UK, national surveys have demonstrated obesity to be higher in low social classes (Rennie & Jebb, 2005). For example, a nationally representative sample of 1836 UK young people aged 4-18 years demonstrated obesity to be more frequent in lower social classes (Jebb et al., 2004). In Plymouth, a study of 20,973 children aged 5-14 years found that rates of obesity were significantly positively correlated with deprivation (Kinra et al., 2000).

A longitudinal study of 2193 American children (Strauss & Knight, 1999) demonstrated that children with low family incomes had elevated risk of becoming obese. Children living with single mothers, less educated mothers and whose parents did not work were also at increased risk for obesity, but these associations may be mediated through the effects of low income. Also in young American children, those in wealthier families and with better educated parents had lower BMIs and were less likely to be overweight (Snell et al., 2007).

The influence of SES on childhood obesity may extend to adulthood. A systematic review of childhood predictors of adult obesity (Parsons et al., 1999) concluded that there is a strong and consistent correlation between low SES in early life and increased fatness in adulthood. SES is particularly important for young children, since its influences are most marked between birth and 7 years of age, and have a long-lasting association with risk of obesity in adulthood (Power et al., 2003).

Further to a direct association of socio-demographic characteristics with obesity prevalence, there is an association with obesity risk factors (specifically dietary and activity behaviours). Regarding food intake, diets of individuals in lower socioeconomic groups are characterised by higher intake of fat and sugar and lower intake of fruit and vegetables (James et al., 1997). A study of food consumption in the ALSPAC cohort (10,139 3-year-old British children) found diets based on convenience foods to be more common in children with younger, less educated mothers, and with older siblings (North et al., 2000). Diets based on frequent consumption of healthy foods were more common amongst children with better educated mothers, whilst snacks were more common in socially advantaged families, and in children with older siblings. Maternal education has also been found to be inversely correlated with added sugar intake in preschool children (Kranz & Siega-Riz, 2002), whilst British children in lower socioeconomic groups were documented as having lower intakes of many micronutrients, and a greater intake of energy from fat and snacks (Ruxton et al., 1996). A review by Patrick & Nicklas (2005) concluded that there is growing evidence to support a role of family and social environments in childrens' eating patterns and diet quality; specifically, working parents and busy families may rely on convenience foods and spend less time preparing food; and income can present a barrier to healthy eating, with children in lower socioeconomic groups eating fewer fruit and vegetables and having a greater intake of fat compared to higher socioeconomic groups.

Socioeconomic influences on children's physical and sedentary activity have also been documented. Regarding physical activity, in Scottish school children, vigorous physical activity was lower among lower socioeconomic groups (Inchley et al., 2005). An examination of media use in children found TV viewing to be associated with demographic variables (Anand & Krosnick, 2005): children of older parents spent less time watching videos and DVDs in particular; children of less well educated parents watched more TV, as did children with fathers who were employed part-time rather than unemployed. Children who lived with a single parent watched less TV compared to those with married parents. Contrastingly, other studies have found children in single parent households to watch more TV compared to children with both parents present (Gentile & Walsh, 2002). Brown et al. (1990) found that lack of access to parents, due to employment or absence of fathers from the home, generally increased the time children spent watching TV. A review by Gorely et al. (2004) found that in children aged 2-18 years, TV viewing was consistently negatively associated with parental income and education level. In the American preschool sample studied by Dennison et al. (2002), children whose parents had not completed high school watched more TV than those whose parents had completed high school or further education; and Bernard-Bonnin et al. (1991) similarly found children's TV viewing to be longer in children whose mothers had low levels of education.

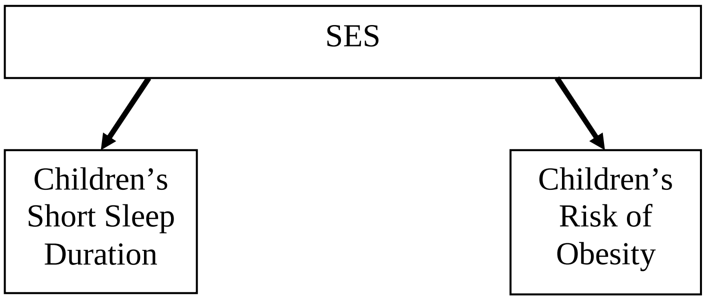
Similarly to sleep, SES and ethnic variation in obesity prevalence, and dietary and activity risk factors, may be partly attributed to the physical environment (French et al., 2001); for example, there is suggestion that low-income and ethnic minority populations experience greater environmental challenges to being physically active and achieving healthy dietary habits (Taylor et al., 2006). Furthermore, it has been proposed that the higher prevalence of obesity in low-income populations may be partly explained by the low cost of energy-dense (obesity-promoting) foods, with the least expensive foods being those with the highest energy density, leading those with limited income to rely on energy-dense foods (Drewnowski & Specter, 2004).

Alternatively to physical environmental explanations, upon finding a negative relationship between parents' education level and TV viewing in children aged 1-12 years, Bickham et al. (2003) suggested that better educated parents have different values which lead them to discourage TV viewing and to advocate other activities instead; particularly, they may be more likely to have books in the house, and to engage in and value reading. Indeed, in children as young as 3-years-old, TV viewing has been found to be less frequent and reading more frequent with increasing parental education (Bianchi & Robinson, 1997). Other documented demographic predictors of reading include children without older siblings reading more, and reading being less frequent in children with employed compared to unemployed fathers, and children living with a single parent rather than married parents (Anand & Krosnick 2005): perhaps the absence of one parent leads to more time constraints and less availability of the remaining parent to read. This hypothesis suggests that parental attitudes and values vary according to SES, which is in keeping with the SES-related variation in attitudes and practices surrounding sleep suggested above.

Socio-Demographic Characteristics in the Childhood Sleep-Obesity Link

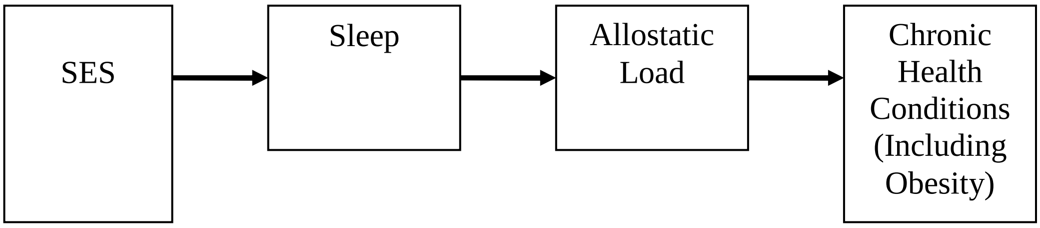
Sleep-obesity research has found the association to be independent of SES and demographic characteristics. However, there is inconsistency in the markers used. The evidence presented here suggests that sleep and obesity vary with social and demographic characteristics: perhaps they explain some of the relationship between short sleep and obesity. For example, short sleep and obesity are more prevalent in lower SES groups, with less well educated parents; perhaps SES confounds the sleep-obesity relationship (see Figure 3.7).

Figure 3.7: Potential Confounding Role of SES in the Sleep-Obesity Relationship



Alternatively, as hypothesised by Van Cauter & Spiegel (1999), sleep may mediate the relationship between SES and health. Van Cauter & Spiegel observed that reduced sleep sufficiency and quality in low SES adults is associated with increased "allostatic load" (dysfunction of neuroendocrine responses to stress; McEwen & Stellar, 1993), and subsequent development of chronic conditions (including obesity) which are more prevalent in low SES groups (see Figure 3.8).

Figure 3.8: A Hypothesis for Sleep as a Mediator of SES Variation in Health (based on Van Cauter and Spiegel, 1999)

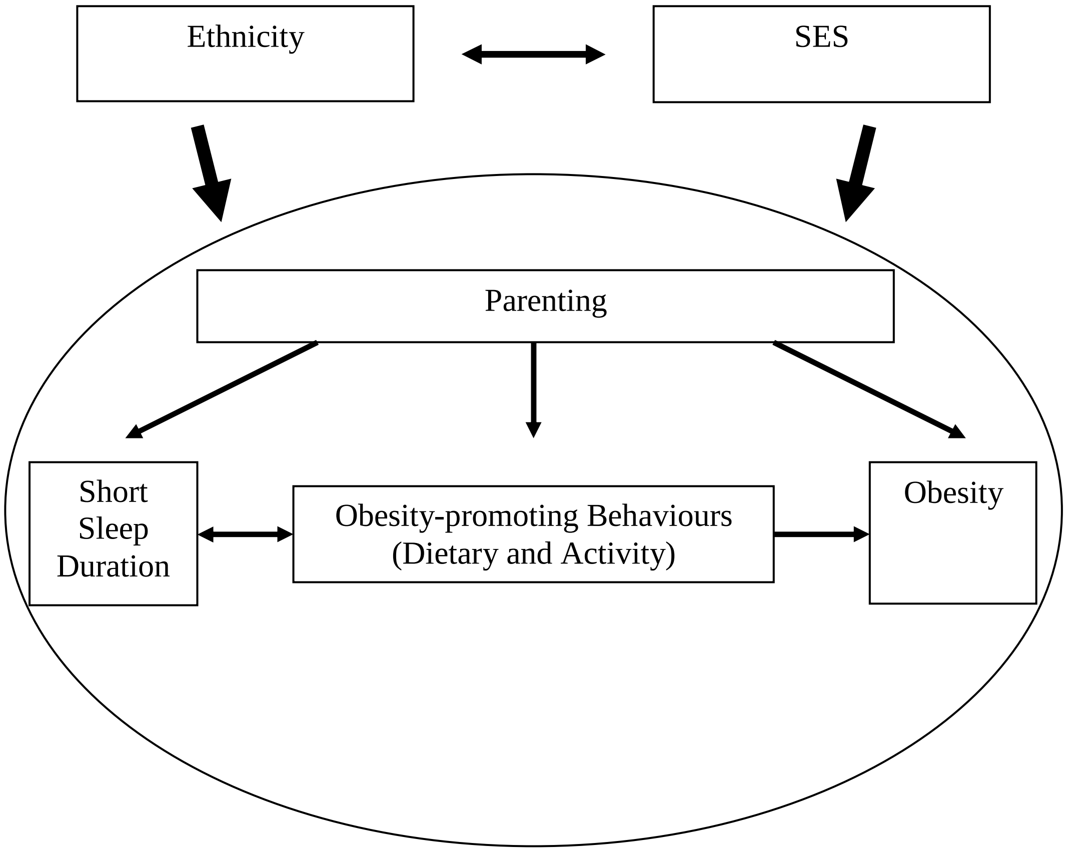


Furthermore, crude SES and demographic markers have been used in sleep-obesity research, such as household income, parents' education level, and family composition; these crude measures do not consider the complexity of cultural and social attitudes and values, and how these may contribute to the sleep-obesity link (see below).

Summary: Ethnicity and Socio-Demographic Characteristics in the Childhood Sleep-Obesity Link

Sleep and obesity vary with both ethnicity and socio-demographic characteristics, particularly SES; hence these factors may shed light on potential mechanisms linking short sleep with obesity, and the context of the relationship. Causes of ethnic and SES variation may be differences in the physical environment, or parents' attitudes and values (see below). In addition to their association with sleep and obesity, ethnicity and SES are frequently correlated together. This thesis will explore the ethnic and SES context of the sleep-obesity link in order to generate new insights into the relationship of sleep with obesity; these characteristics are added to the previous model (Model B) as shown in Figure 3.9, Model C.

Figure 3.9: Model C for Exploration: Potential Impact of Ethnicity and SES on the Childhood Sleep-Obesity Link



Cultural Attitudes and Values in the Childhood Sleep-Obesity Link

Studies of the sleep-obesity association have been carried out in different countries and ethnic groups, and have controlled for crude SES and demographic markers such as household income, parents' education level, and family composition. However, these crude measures do not consider the complexity of cultural and social attitudes and values, and how these may contribute to the sleep-obesity link. There is some suggestion that ethnic and socio-demographic variation in children's sleep and obesity-promoting behaviours stem from parents' values and attitudes (mentioned above).

Furthermore, individual parenting behaviours are responsive to the cultural and social context in which they are practiced. Therefore, in order to understand parents' behaviours and practices (regarding children's sleep, diet and activity), it is helpful to consider the wider social and cultural context.

Attitudes and Values Regarding Sleep

Regarding sleep, cultural attitudes and expectations determine the appropriate or "normal" scheduling, timing and location of sleep, such as whether sleep should be consolidated or segmented, what is a desirable time for sleep throughout the day, and where should sleep occur.

In Western societies, institutions and conventions demand that children and adults alike are awake and functioning at certain times of day, leaving sleep to occur at night. Whilst sleeping during the day is inappropriate, discouraged and avoided in American and Northern European societies (except for infants and young children), other cultures have institutionalised siesta or nap periods, to the extent that businesses and social interactions cease. For preschool children in particular, some cultures include regulated, enforced nap periods in day-care settings, whilst others do not, or even discourage sleep in day-care. For still other cultures, the distinction between being asleep and awake is more fluid: for example, in non-industrialised societies there is no formalised bedtime, and spontaneous daytime napping is acceptable and commonplace (Worthman & Melby, 2002).

Bedtime practices are influenced by cultural and social norms and expectations. In a study of a Mayan community in Guatemala, children were found to fall asleep when they were sleepy, and no bedtime routines or specific sleeping clothes were identified (Morelli et al., 1992). Lack of a rigid bedtime was also observed in Italy, where children are expected to participate in the evening family events, and fall asleep when they are tired, often in someone's lap. This is in contrast to American children who are more commonly required to adhere to set sleep schedules, going to bed even when they are not sleepy (New & Richman, 1996).

Values placed on independence or inter-dependence of individuals influence sleep practices and particularly sleep location. Western societies value independence for children and strive for children to sleep alone throughout the night; other cultures value inter-dependence and collectivism, including shared sleep place (Jenni & O'Connor, 2005).

Regulation of sleep and independent sleep in Western societies reflects how sleep is closely tied to a moral framework which dictates that "good" sleep for children is independent, consolidated sleep, and that this is an indication of "good" parenting and "good", well-regulated children. Parents are responsible for training their children to sleep independently, which they achieve by setting regular sleep schedules, with children sleeping in a room of their own with limited or no parental interaction through the night (Worthman, 2010). The moral attributes assigned to children's sleep regulation exert social pressure on parents, who must conform to these cultural norms in order to be "good" parents:

> *"connections between sleep behaviour and the moral order of the larger society are a cultural commonplace and figure predominantly among the reasons such deep feelings are attached to the propriety of child sleep behaviours and why preferred patterns of child sleep are so strongly resistant to acculturative pressures."* (Jenni & O'Connor, 2005 p. 213)

Attitudes and Values Regarding Obesity

Cultural attitudes and customs affect obesity by influencing activity and dietary behaviours. Culturally-influenced determinants of childhood obesity include eating patterns and food beliefs (NOO, 2011), social interactions around food, amount of TV viewing, and participation in sports or active recreation (Kumanyika, 2008). For parents, individual behaviours related to childhood obesity are responsive to the contexts in which they are practiced (Booth et al., 2001; Wetter et al., 2001); therefore culturally-influenced parenting practices include child feeding practices, the types of foods available in the home and the access that children have to these foods, and the activities which children undertake.

Attitudes and Values in the Childhood Sleep-Obesity Link

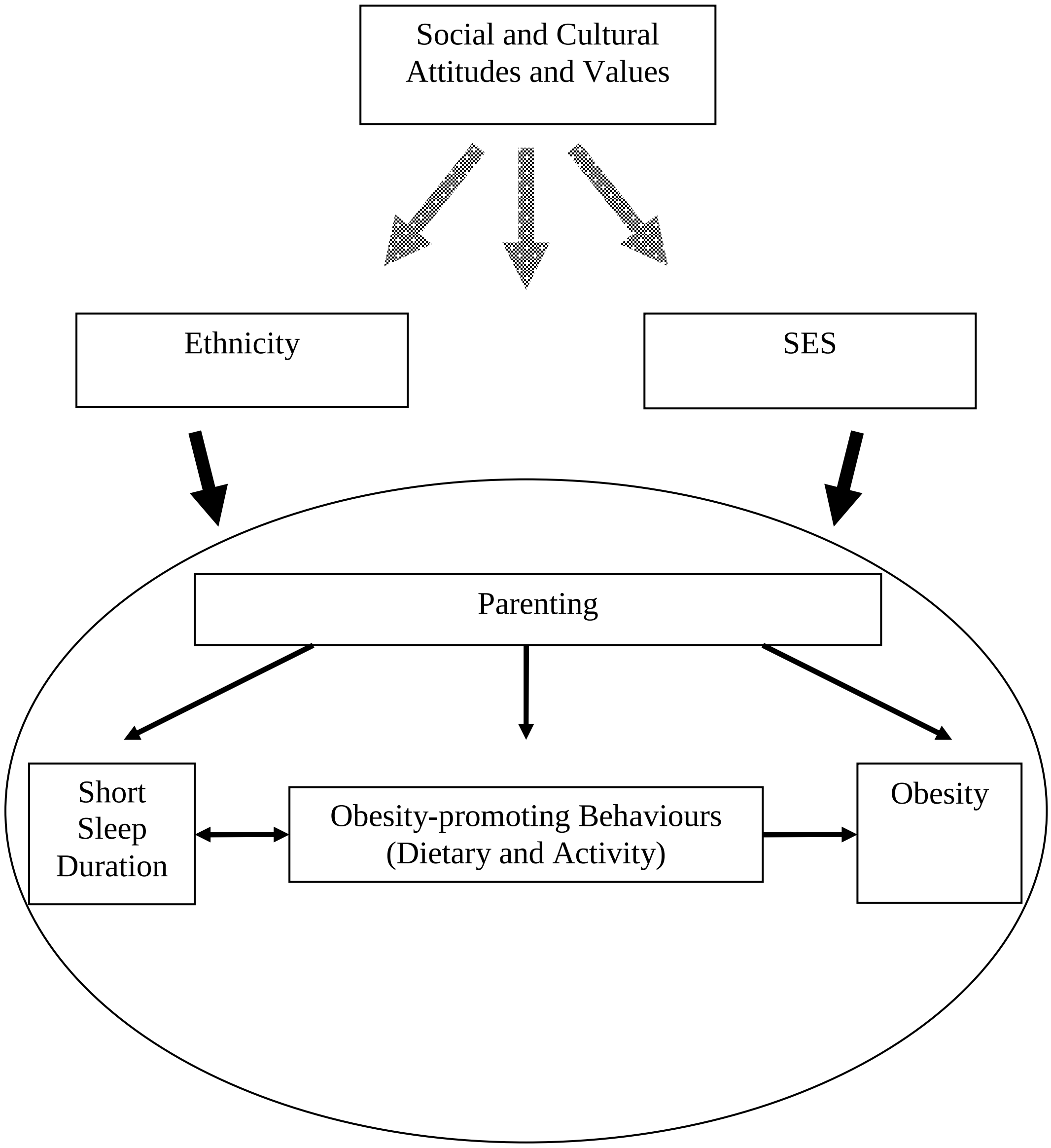
Parents' attitudes and practices regarding their children's sleep, diet and activities are strongly influenced by cultural expectations and values. Wider social and cultural attitudes and values can therefore influence children's sleep and obesity risk via parents' behaviours. A more holistic exploration of the role of dietary and activity behaviours, and the role of parenting in the sleep-obesity link, must therefore consider wider social and cultural attitudes and values.

Furthermore, ethnic and socio-demographic variation may arise due to engrained variation in attitudes and expectations. Studies into the relationship between short sleep and obesity have controlled for crude indicators of SES and for ethnicity and nationality; understanding attitudes and values in addition to crude ethnic and SES variation is important for a holistic understanding of the sleep-obesity link.

Summary: Cultural Attitudes and Values in the Childhood Sleep-Obesity Link

Social and cultural attitudes and values influence children's sleep, diet and activity behaviours, and risk of obesity, in addition to parenting. Furthermore, variation in values and expectations may contribute to ethnic and socio-demographic variation in children's sleep and obesity risk. In order to gain a more holistic understanding of the sleep-obesity relationship, this thesis will explore the wider context of social and cultural attitudes and values in relation to each of these aspects, building on the previous model (Model C) as shown in Figure 3.10, Model D.

Figure 3.10: Model D for Exploration: Wider Social and Cultural Context of the Childhood Sleep-Obesity Link



Evolutionary Medicine, Sleep and Obesity

As described in Chapter 1, evolutionary medicine has been applied to the study of obesity, and may be an effective and novel perspective from which to study the sleep-obesity link. Evolutionary medicine uses an evolutionary perspective to understand health and disease, and provides new insights into medical issues (Nesse & Williams, 1994). A key area is the mismatch between human biology and contemporary Western lifestyles and environments. Children's biological makeup reflects adaptation to an environment which is different from the one experienced in contemporary industrialised societies: this was coined the Discordance Hypothesis by Eaton et al. (1988). Hence changing evolutionary environments have negative consequences for children's health because conditions are discordant with those for optimal development.

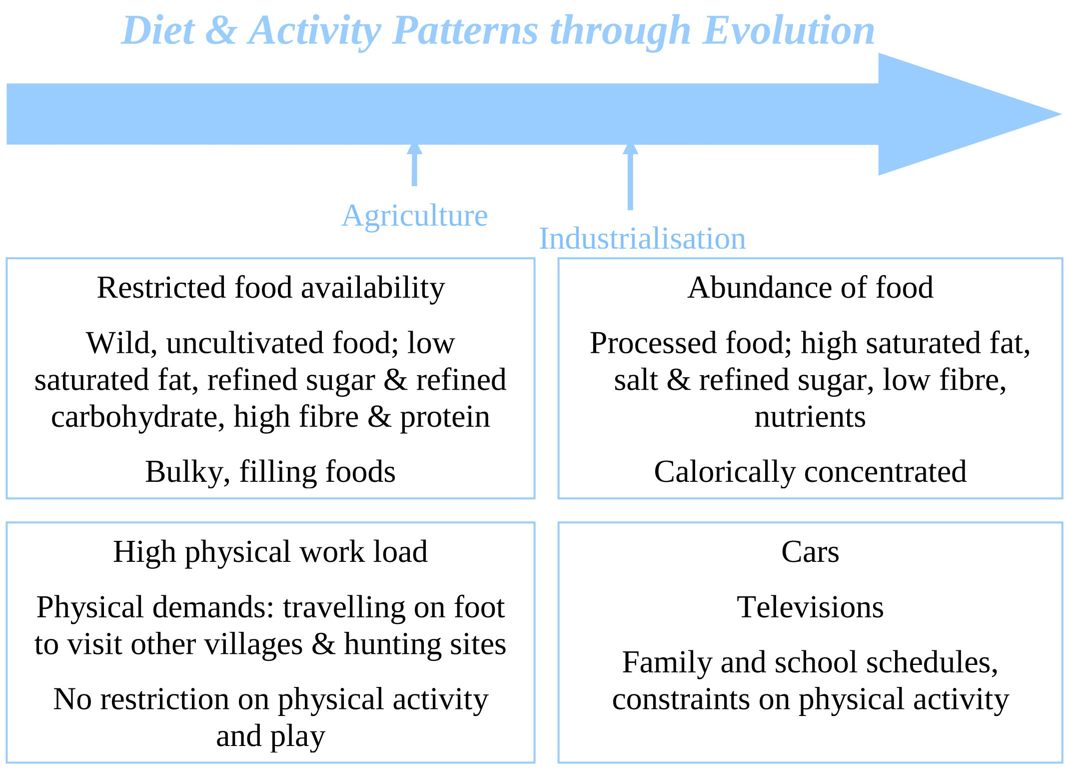
Obesity is a key example of the application of evolutionary medicine and the Discordance Hypothesis to explain modern health issues. However, this perspective has not been applied to the study of the sleep-obesity link. The application of evolutionary medicine to explain rising obesity prevalence is described below, followed by a discussion of what is known about the evolutionary ecology of sleep, and then consideration of the potential to apply evolutionary theory to the sleep-obesity link.

Evolutionary Medicine and Obesity

The rising prevalence of childhood obesity has been widely attributed to the change in children's diets and activity patterns through evolution. Human nutritional requirements have been shaped by eating patterns during millions of years of hominid evolution. For ancestral humans, the quantity and types of foods eaten were regulated environmentally. Food intake was restricted by environmental availability, and limited cooking and storage methods required wild, uncultivated foods to be eaten mainly raw. Foods which were available were low in calorie-density, saturated fat, and refined sugar and carbohydrate, whilst high in nutrients and protein; and foods were bulky and filling. Demands for physical activity were high: even in young children in Palaeolithic times there were demands to travel long distances by foot. Furthermore, there was no restriction of physical activity and play (see Eaton et al., 1988).

Dietary patterns changed markedly with the adoption of agriculture, which brought about an artificial abundance of food and a change in availability of food types, cooking and storage methods. Major differences in foods eaten since the domestication of plants and animals include the percentage of calories obtained from fats, protein and carbohydrate, and intake of cholesterol (Trevathan et al., 2008). Further changes occurred with industrialisation: foods have become more calorically concentrated and of denser nutritional content. Regarding activity, advances in motorised transport and technology in Westernised societies have reduced the need for physical activity, and enabled travel to become physically undemanding. The development of work and school schedules has led to a decrease in physical play time for children, accompanied by the availability of TVs and computers, which have increased sedentary activity (Eaton et al., 1988). A model for these proposed changes in diet and activity patterns through evolution is shown in Figure 3.11.

Figure 3.11: Change in Human Diet and Activity Patterns through Evolution



Although evolutionary changes are gradual and there are no distinct or discrete periods, since human biology is adapted to changing environmental conditions over millions of years, for simplification and the purposes of this discussion, contrasts are drawn between environments in 1) ancestral and non-industrialised societies, and 2) industrialised and Westernised societies.

For ancestral humans, and in non-industrialised societies today, the types and quantities of foods available, in combination with relatively high physical activity demands, ensured that risk of obesity was low. Comparatively, the mismatch between environments and experiences of children in industrialised societies today, and those which are most optimal biologically, has led to risk of weight gain and obesity. Children are able to be less physically active and more sedentary, in an environment in which food, including fatty, sugary, calorically-dense foods, is readily available, which leads to weight gain and obesity. Hence evolutionary medicine has formed a widely recognised theory to explain the observed obesity epidemic. However, an evolutionary medicine perspective has not been applied to the relationship of obesity with short sleep. In order to implement this perspective it is necessary to explore what is known about an evolutionary approach to sleep.

Evolutionary Medicine and Sleep

In comparison with obesity, studies of human sleep have been neglectful of its adaptive and evolutionary context (Trevathan et al., 2008). However, considering the origins and functions of sleep, and how current sleep patterns vary from those of ancestral humans, may enable further understanding of current sleep patterns, associations with health, and increasing prevalence of sleep-related ill-health (including obesity).

Sleep has clearly been important throughout evolution, as demonstrated by the extensive prevalence of sleep amongst animals (Nesse & Williams, 1994), and the poor functioning of sleep-deprived animals, which is particularly well-documented in humans (Rosenthal & Meixner, 2002). Meddis (1974) first proposed that the amount and timing of sleep were set by the potential for productive activity: the dangers associated with being mobile at night (for example predation), in the absence of productivity potential (due to darkness), resulted in the most optimal survival strategy being a daily cycle of activity, with rest and inactivity during the night. Recent cross-species comparative analyses and sleep-deprivation studies support the role of sleep in saving energy and keeping species from being active at inopportune times (Siegel, 2005). The variation of mammalian sleep across species in relation to differential predation pressure (for example the safety of sleeping sites) and foraging requirements (for example dietary type) further supports the role of ecological factors in driving the evolution of sleep patterns (Capellini et al., 2008).

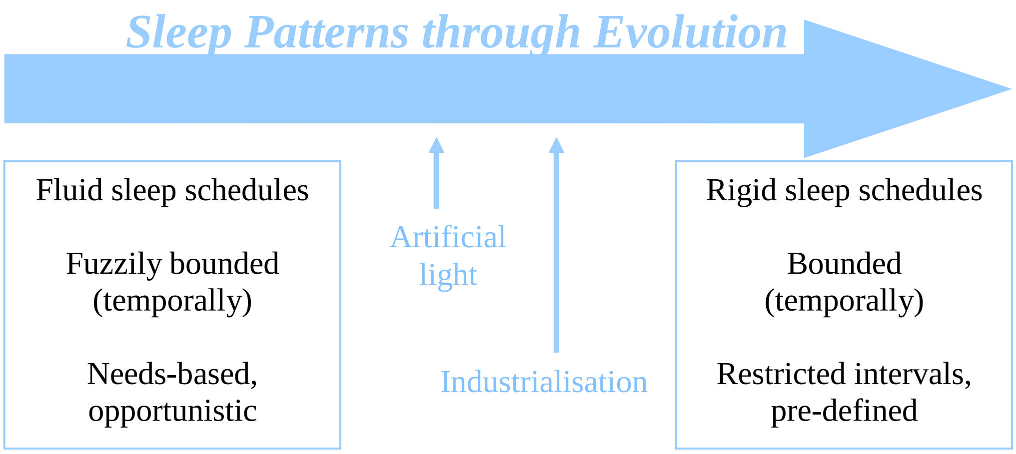
Whilst the timing, length and regularity of sleep before the nineteenth century remains a conundrum, ancestral human sleep is thought to have been segmented rather than consolidated. Wehr and collegues (1993) conducted a landmark study, exposing 15 volunteers to daily 14 hour “night” periods of darkness. By the end of the month-long study, subjects slept on average for 8 hours per night, in two distinct periods separated by a period of wakefulness. The authors concluded that this segmented sleep was representative of ancestral human sleeping patterns. In a social historical examination of sleep in England, Ekirch (2001) also posited that until the close of the early modern era, Western European sleep was characterised by two distinct periods of sleep, bridged by an hour or more of quiet wakefulness. He further proposed that in pre-industrial England, sleep onset occurred at dusk, and lasted until dawn; though this long period of sleep opportunity was vulnerable to intermittent disruption due to threat, discomfort, and illness.

Still in non-industrialised societies today, regular periods of darkness and daily cycles of activity provide regular and predictable nighttime sleep periods, and sleep schedules during daylight periods are fluid and unbounded. Sleep occurs opportunistically and when needed; people are able to drift in and out of sleep throughout the day as well as at night, and are unlikely to experience restriction of sleep time (Worthman & Melby, 2002).

In Western Europe, technological advances have altered sleep patterning. The advent of artificial light has gradually reduced the nighttime period (Ekirch, 2005). The influence of artificial light on sleep may have begun as early as the discovery of fire and candle-light, but was most pronounced by gas and then electrical lighting. Beginning in the late seventeenth century (with increasing availability of artificial light), segmented sleep grew less common; and by the nineteenth century in England, nighttime, and with it sleep opportunity, were further eroded by industrialisation. Highly scheduled and organised daytime periods, aided by mechanised devices for waking as well as artificial light, have led to maximisation of active time and restriction of sleep time; indeed, in adults, too little time for sleep is a self-reported cause of insufficient sleep (Broman et al., 1996). Society demands conformation to standardised schedules and expects people to be available and functional at specific times of day (Jenni & O’Connor, 2005); these cultural values and social demands influence sleep patterns of even young children, who must conform to parents’ work and their own nursery schedules, and to cultural expectations for scheduled nighttime sleep. All-night entertainment such as TV has also contributed to nighttime restriction. In some industrialised countries, the acceptability of daytime napping in all sectors has been diminished by governmental legal decree, which demonstrates the restriction of daytime sleep opportunity as a consequence of globalization and "24/7" economies (Jenni & O'Connor, 2005).

Hence ancestral sleep patterns have been masked by artificial light and pressures for productivity in industrialised societies (Wehr et al., 1993). Sleep patterns are no longer fluid and unbounded, instead being restricted to pre-defined, culturally appropriate sleep periods, which are regulated and restricted by scheduling constraints (Worthman & Melby, 2002). A model for this proposed change in sleep patterning through evolution is shown in Figure 3.12.

Figure 3.12: Change in Human Sleep Patterns through Evolution



Consequences of this change in sleep patterning are undetermined; perhaps there is discordance between modern sleep patterns and those to which biological makeup is adapted, contributing to suboptimal development and sleep-related ill-health (including obesity). Indeed, Jenni & O'Connor (2005) question the goodness of fit between children's biological sleep needs and their culturally normative bedtime practices:

> "*Are the cultural standards provided by our own society optimal for the development of our children*?" (p. 214)

Evolutionary Medicine and the Sleep-Obesity Link

In sum, discordance between contemporary Western lifestyles and conditions optimal for human biology can explain the increasing prevalence of obesity. Whilst less is known about the evolutionary context of sleep, it is thought that sleeping patterns have changed through evolution, and modern sleeping patterns could be discordant with those of evolutionary adaptedness.

These theories, coupled with the importance of an evolutionary approach to health research (see Chapter 1), suggest that taking an evolutionary perspective could enable further insight into the sleep-obesity link. Indeed, it has been proposed that:

> "*Nothing in medicine makes sense except in the light of evolution.*"
> (Swynghedauw, 2008, manuscript title)

Given the potential of evolutionary medicine, I will take a novel approach to the study of the sleep-obesity link and interpret the results of this study using an evolutionary medicine perspective.

Chapter 3 Summary: Literature Review: Causes and Context of the Childhood Sleep-Obesity Link

This chapter has presented the rationale for behavioural mechanisms being implicated in the sleep-obesity link, in particular dietary and activity behaviours. It has also presented the rationale for parenting being a potential confounder of the sleep-obesity relationship in young children. The association of ethnicity and socio-demographic characteristics with both sleep and obesity has been reviewed, the importance of considering the wider social and cultural context has been explained, and the potential of these factors to further our understanding of the sleep-obesity link has been outlined. The potential of an evolutionary medicine perspective to enable further insight into the sleep-obesity link has also been proposed.

In light of this literature review, this study aimed to take a holistic approach to exploring the sleep-obesity link in young children, exploring potential behavioural mechanisms (dietary and activity behaviours), parenting, the involvement of ethnicity and socio-demographic characteristics and the wider social and cultural context, and taking an evolutionary medicine perspective. This answers the call by Hart & Jelalian (2008), who proposed that:

> *"additional variables such as parenting behaviours and skills, and cultural norms… should be assessed in future studies to determine what role, if any, these variables may play in the associations between sleep duration and overweight… Parental limit-setting skills may be important for appropriate weight control, as well as the promotion of healthy sleep habits… which would encourage appropriate sleep duration. Thus, future research would benefit from evaluation of other variables that may influence the relationship between sleep duration and weight status."* (p. 262)

It also answers calls that a thorough understanding of biology and health must include a consideration of the effects of evolution (Trevathan et al., 2008).

Research Aims

As presented in Chapter 1, the objectives of this study were to:

- OBJECTIVE ONE: Conduct a detailed exploratory investigation into the link between short sleep and obesity in preschool children.
- OBJECTIVE TWO: Apply an evolutionary medicine perspective to the study of the sleep-obesity link.

Chapter 2 described the need to explore the mechanisms linking sleep and obesity in young children, particularly behavioural pathways and potential confounding variables. This chapter has presented specific potential areas for investigation, to explore in this study. Specifically, the aims of this study were to:

- AIM ONE: Explore potential behavioural mechanisms linking short sleep and obesity in preschool children, particularly obesity-promoting dietary and activity behaviours
- AIM TWO: Explore the potential role of parenting in the childhood sleep-obesity link
- AIM THREE: Consider ethnicity and SES, and the wider impact of social and cultural attitudes and values in relation to the childhood sleep-obesity link

As described in Chapter 2, secondary aims of this study were to:

- SECONDARY AIM ONE: Improve on sleep measures used to examine the sleep-obesity relationship, particularly to assess sleep over a longer period (rather than a single night or parent-report of a typical night); assess variability in sleep duration (including week/weekend day and seasonal variation); and include naps in addition to nighttime sleep
- SECONDARY AIM TWO: Examine waist circumference and skinfold thickness in addition to BMI, to add to the growing body of literature examining relationships between sleep and more direct measures of central adiposity
- SECONDARY AIM THREE: Conduct a detailed investigation into sleep in a sample of preschool children, to add to the limited literature regarding children's sleep

The limited knowledge of these topics and their role, if any, in the sleep-obesity link, meant that no specific hypotheses were proposed. This was an exploratory study, using a combination of quantitative and qualitative methods to explore the above aims, in order to generate hypotheses for future research.

Addressing of Aims throughout the Thesis

The next chapter will describe the study design and research methods, including a discussion of exploratory research and mixed methods.

Chapter 5 will describe the characteristics of the sample; it will then present some initial analyses, particularly regarding variability in children's behaviours, and correlations of children's sleep measures with body composition (secondary aims one and two).

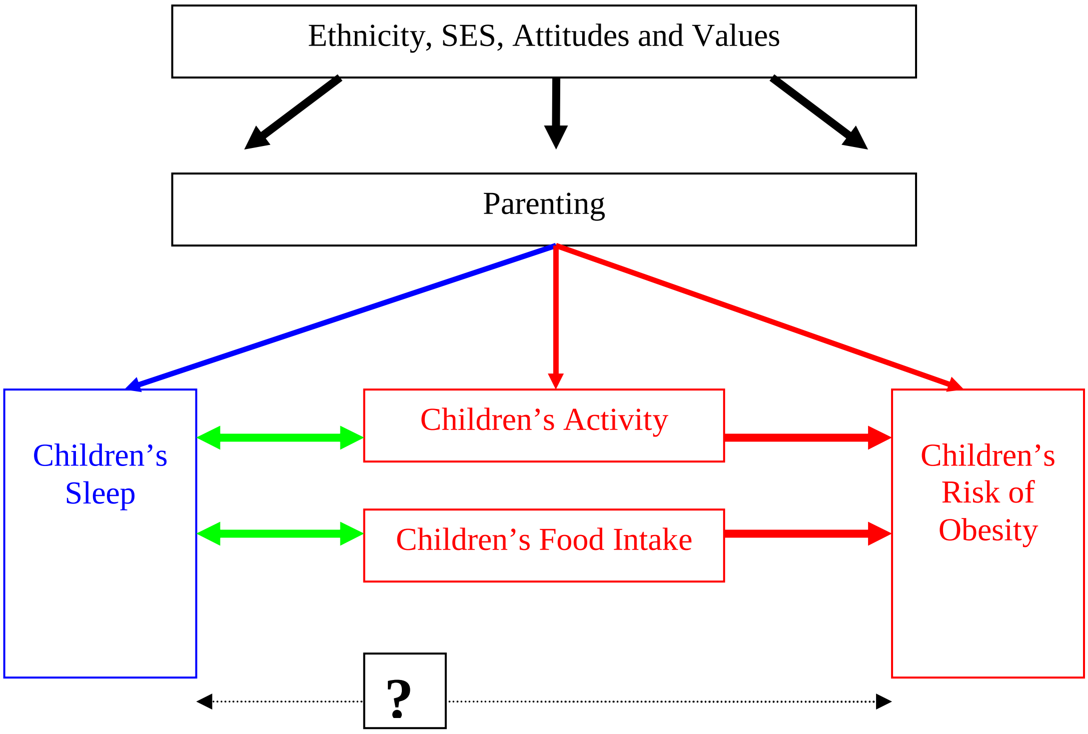
The following chapters will address the primary aims. Chapter 6 will describe children's sleep (secondary aim three), parents' attitudes and values regarding sleep, and potential associations between parenting and children's sleep. Chapter 7 will describe children's dietary and activity behaviours, their parents' attitudes and values regarding diet and activity, and potential associations of parenting with children's activity and dietary behaviours and body composition. Chapter 8 will assess potential correlations of children's sleep with dietary and activity behaviours (aim one). It will then combine and expand on the results of chapters 6 and 7 in order to assess the potential role of parenting in the sleep-obesity link (aim two).

Throughout each of the chapters, associations of ethnicity and SES with each of the variables will be assessed; similarly, attitudes and values will be investigated throughout chapters 6, 7 and 8 (aim three).

Chapter 9 will use an evolutionary medicine approach to interpret the findings, and consider an evolutionary medicine perspective in the childhood sleep-obesity link.

The content of chapters 6, 7 and 8, and how they relate to the model to be explored, is summarised in Figure 3.13 (note that bi-directional arrows indicate potential reverse causation).

Figure 3.13: Thesis Outline: Aims Addressed in Each Chapter



KEY:
Dotted line = the association to be explored in this study
Blue = Chapter 6
Red = Chapter 7
Green = Chapter 8
Black = Chapters 6, 7 and 8

Chapter 4: Methods

This chapter will convey the study design and methodology; specifically, it will a) outline the study design, b) describe the participants and setting, c) discuss the research methods, and d) explain the data analysis process.

Study Design

This was designed to be an exploratory study to gain insight into the research aims set out in Chapter 3. Exploratory research is a distinctive process which aims to investigate a problem or topic which has not been clearly defined, and for which there are no explicit expectations (Stebbins, 2001). An exploratory design was appropriate because there were no clear evidence-based hypotheses; this study aimed to explore the topic and to generate hypotheses for future research.

The setting, participants, recruitment strategy, research methods and data analyses were selected and designed as appropriate for an exploratory study into this topic. Participants were 3-year-old children and their parents, approached opportunistically at government-funded nursery schools in Stockton-on-Tees. A mixed methods design was employed, using both qualitative methods (interviews with parents) and quantitative methods (diaries with parents, and anthropometric measurements and actigraphy with children). These methods were integrated at the data collection and analysis stages. Hypotheses were generated based on the results from the qualitative data, quantitative data, and literature review (Chapters 2 and 3).

Setting and Participants

This section of the chapter will describe the research location, the study population and recruitment strategy. Also discussed will be the timing of the study, and the ethical approval and funding sources.

Study Location

The location for the study was Stockton-on-Tees, a Borough in the Tees Valley in North-East England, with a population of over 187,000. Since North-East England has amongst the highest rates of childhood overweight/ obesity in England (Crowther et al., 2005), this is a good area for research involving obesity. Table 4.1 shows the proportion of overweight and obese children in regions in England: for girls, the North-East experiences the greatest overweight/ obesity rate of any region, whilst for boys the North East nears the greatest overweight/ obesity rate nationally.

Table 4.1: Overweight and Obesity Prevalence in Children by Region, 2005-2007

Overweight or Obese (%)	Region							
	North East	North West	Yorkshire & Humber	East Midlands	West Midlands	East England	London	South West
Boys	33	30	30	31	34	30	34	29
Girls	32	32	31	30	31	25	30	29

Data obtained from NHS Information Centre, 2009

Stockton-on-Tees is economically and socially diverse. Fifteen percent of the population live within the top 20% most affluent areas nationally, and 34% in the 20% most deprived areas nationally (see Stockton Borough Council). SES is associated with both children’s sleep and risk of obesity (see Chapter 3), hence inclusion of diverse SES groups was an important component of this investigation. This study distinguished between two groups of participants: economically affluent and economically deprived; accordingly, areas within Stockton-on-Tees were identified which are particularly affluent and deprived, enabling inclusion of diverse SES groups from the same geographic location.

The proportion of ethnic minority residents in Stockton-on-Tees (2.8%) is smaller than the national average (9.1%; based on the 2001 Census, see Stockton Borough Council), and the majority of BME residents are of Pakistani origin. The non-white population in Stockton is more concentrated in certain wards, and some of these wards were selected for the study to enable inclusion of BME families. The study aimed to recruit a sample of families who were representative of the area, and so specific ethnic groups were neither targeted nor excluded.

Within Stockton-on-Tees, I conducted the study at nursery schools attached to government-funded primary schools. All 3-year-old children in England are entitled to 15 hours of free nursery education for 38 weeks of the year. This nursery education includes school nurseries; at primary school nurseries this is arranged as either a morning or afternoon session of nursery each day of the school year. Since all 3-year-old British children are entitled to a nursery place free of charge at government-funded primary school nurseries, characteristics of families attending these nurseries should be representative of the surrounding area, rather than restricted to specific groups (for example fee-paying nurseries may be restricted to families with higher incomes, and work-place nurseries to families with employed parents).

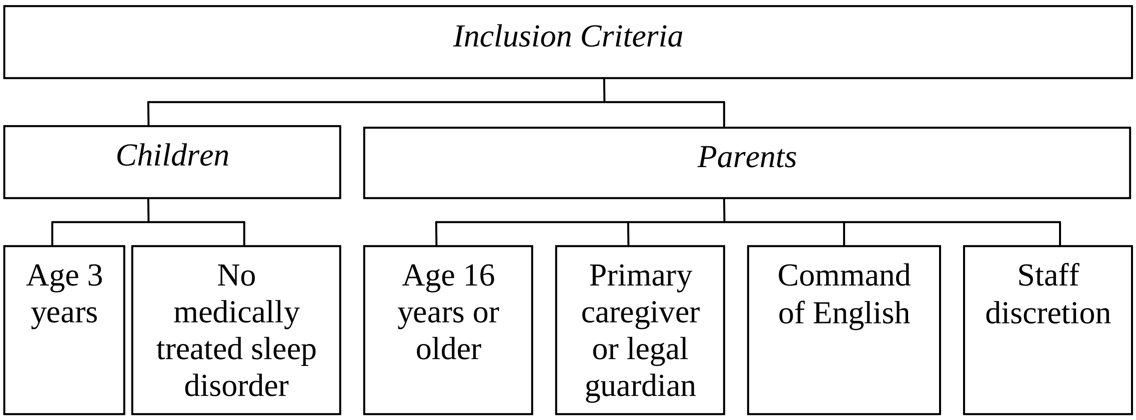
Study Population and Inclusion Criteria

Participants were 3-year-old children and their parents or primary caregivers. Inclusion criteria are shown in Figure 4.1. Preschool children were the focus of the study, since the sleep-obesity link is strongest for young children, begins longitudinally at preschool age, and obesity interventions should begin in early childhood (see Chapter 1). Participation was limited to children aged 3 years, rather than all preschool children, so that age-related variation in children’s sleep and behaviours would not influence the findings. This study aimed to examine children’s typical sleep patterns; any children being medically treated for a sleep disorder were therefore excluded. To examine the association of sleep with obesity, it was desirable to include children with different weight statuses; children were not excluded on the basis of body composition.

Primary caregivers who participated with their children were required to be their parents or legal guardians (throughout this thesis, primary caregivers who participated are referred to as “parents”; this includes legal guardians who were not biological parents). Where children’s parents were separated, then the parent with whom they spent the most time participated in the study.

Caregivers other than parents or legal guardians (for example childminders, nursery staff, grandparents) did not participate, since specifically primary caregivers' attitudes and behaviours were the focus of this study. Furthermore, other caregivers may have been unable to comment on all aspects of children's sleep, diet and activities, particularly at nighttime, evenings or weekends, if they were not with the children during these periods. A minimum age of 16 years for caregivers was required to prevent issues obtaining informed consent, and they were required to speak English well enough to be interviewed in English and to complete a diary in written English. Some children and their parents were excluded on the basis of nursery staff discretion; staff advised me not to approach families when police or social services were involved, parents were experiencing mental illness, or for other reasons.

Figure 4.1: Inclusion Criteria for Children and Parents



Recruitment of Participants

I identified government-funded primary schools with affiliated nursery schools in Stockton-on-Tees by contacting the school admissions section of Stockton Borough Council. Those in the pre-identified deprived and affluent areas were selected. I contacted head-teachers of these schools by letter (see Appendix A: Information Letter for Headteachers) and a follow-up phone call, to inform them of the study and ask for their participation. In some cases the head-teacher referred me to the lead nursery teacher. When teachers expressed interest in participating, I visited them and explained the study, its purpose, and what it would involve. Practicalities were discussed (such as convenient timing in the school year and suitable locations for interviewing and anthropometric measuring). A member of nursery staff was required to read an information letter and sign a consent form on behalf of the nursery before it participated.

I attended each nursery daily for a period of 1-2 months. Parents were informed of the study and introduced to me by nursery staff. Once I had attended the nursery for 1-2 weeks and had become familiar with the day-to-day running and with the families attending, then I began to approach parents opportunistically as they brought their children to and from nursery. I explained the study verbally, and asked if they would like to participate. Those who consented were required to read an information letter and sign a consent form prior to participation (see below).

I aimed to recruit 80 families with an equal distribution from deprived and affluent areas. Similar numbers of nurseries in deprived and affluent areas were contacted, and recruitment continued until the target number was reached in each area. With a national obesity rate of 8% for boys and 11% for girls aged 3 years (Health Survey for England, 2008), a sample size of 80 was considered great enough for children with diverse body composition (including obese children) to be included, whilst allowing good quality and detailed investigation for each family. This was an exploratory study and so power calculations were not necessary.

Since nurseries and families within nurseries were not sampled randomly, any conclusions from the study should not be applied to the whole population from which the sample was drawn. However, the nurseries were selected to represent diverse areas in Stockton-on-Tees, and no 3-year-old children and their families were specifically targeted or excluded, other than on the basis of the inclusion criteria (see Figure 4.1). Opportunistic, non-probability sampling such as this can lead to the generation of new hypotheses, and is a valid method for an exploratory study (Bryman, 2004).

Timing of the Study

I contacted schools in spring 2008, and attended consenting nurseries to collect data between May 2008 and June 2009. I attended each nursery in turn, for between 1-2 months each. Data collection over a calendar year enabled children’s behaviours to be recorded across different seasons, preventing results from being skewed by seasonality.

Nurseries in each area (deprived and affluent) participated in both summer and winter, so that each area was represented across the year.

Ethical Approval and Funding

Approval was gained from Durham University Anthropology Department's ethics committee. I received enhanced disclosure from the Criminal Records Bureau.

Participation was on a voluntary basis, and participants were aware that they were free to withdraw at any time without suffering any negative consequences. A member of staff was required to read and sign a consent form on behalf of each nursery before parents were approached (see Appendix B: Nursery Consent Form). The purpose of the study, what it would involve and its intended possible uses were explained verbally to parents. Parents were then required to read an information letter and complete and sign a consent form prior to participation: a separate information sheet was provided and consent form required for each section of the study so that parents could opt out of different sections (one for interviewing and diaries; one for anthropometrics; one for actigraphy) (see Appendix C: Parent Information Sheets; and Appendix D: Parent Consent Forms). Formal consent was not obtained from children, but they did not participate unless they were happy to do so. I asked parents whether they would consent to me taking photographs of their children to use for scientific purposes (such as presentations); I took photos only of children whose parents had provided written consent.

All study materials were stored securely in accordance with the Data Protection Act 1998, and participants were not identified by name in any formal documents. Once parents had consented to participate, I assigned them a number which was used for identification in study documents. Confidentiality was maintained, but parents were informed prior to participation that this would be broken where legal obligations arose, for example in cases of suspected child neglect or abuse, or where information was requested from court.

The research was funded by a 1+3 joint studentship provided by the ESRC and MRC. In addition, a student fieldwork bursary awarded by the Biosocial Society contributed to fieldwork expenses.

Thank You Gifts and Providing Feedback

I did not provide thank you gifts to parents or nurseries as an incentive to participate. However, throughout the period I spent at each nursery I helped staff and children with daily tasks, for example setting up activities for the children, taking the register, distributing milk, and helping children with activities; I also undertook additional voluntary work such as supervising on nursery trips to the theatre. I continued to volunteer my help at each nursery upon completion of the data collection phase of the study (for example supervising children on nursery sports day, and attending a pantomime production). Assisting staff where possible ensured that my presence was not a burden. Furthermore, I believe that the experience of participating was positive for both parents and children. Many parents spontaneously said that they enjoyed the experience of participating. Children also enjoyed participating and receiving stickers (see below).

Continuing to regularly visit each nursery has allowed me to maintain the good level of rapport which I established with parents, children and nursery staff, and will enable effective feedback of the results to all who participated. I intend to provide a written summary of the results and conclusions to all of the nurseries and families who participated, and to explain these verbally where requested. As well as being an important component of the research, this is another way of compensating participants for their time. Parents and nursery staff were eager to hear about my research, and I believe that feeding back the results will be a further way of improving their experience.

Logo

I named the study the SHINY study (Sleep Habits IN Youngsters). I used this name to refer to myself and the project when I approached nurseries and parents. I created a logo for the study (see Figure 4.2). This logo was used on all documents including information sheets, consent forms, diaries, and anthropometric data collection sheets.

Figure 4.2: The Study's Logo

Sleep Habits IN Youngsters

Summary: Setting and Participants

Participants were 3-year-old children and their parents (or primary caregivers), recruited opportunistically from government-funded nursery schools in Stockton-on-Tees, North-East England. Deprived and affluent areas in Stockton-on-Tees were identified for inclusion in the study over a period of one year. Written informed consent was obtained from nursery schools and parents prior to participation, and confidentiality and anonymity were maintained.

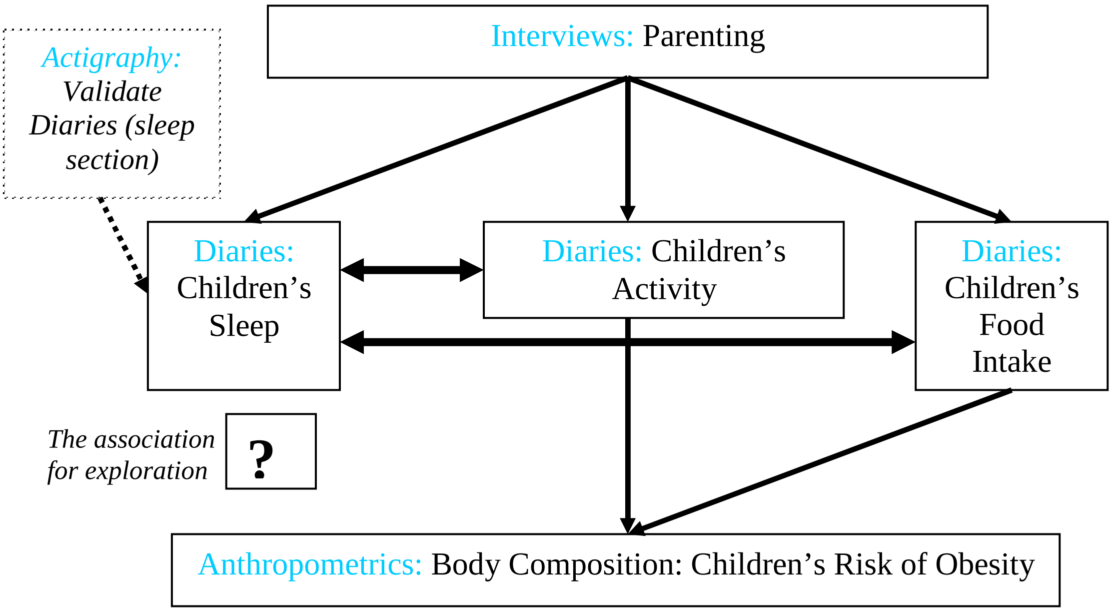
Research Methods

This section of the chapter will present the methodology. The research methods will be described, and the advantages and disadvantages of each method will be discussed.

Methods Overview

This was an exploratory study, which aimed to investigate the research topic in detail, identify themes, and generate hypotheses. I selected different methods to explore different aspects of the research aims as appropriate (see Figure 4.3). Parents' attitudes and practices regarding their children's sleep, diet and activities, and their general approaches to parenting, were explored with semi-structured interviews. Data regarding children's typical daily sleep patterns, food intake and activity levels were elicited with diaries. Actigraphy was used to collect sleep-wake data for a subgroup of children, in order to validate the sleep section of the diaries and assess the accuracy of parental reporting. Children's body composition and obesity status were assessed with anthropometric measurements.

Figure 4.3: Matching of Methods to the Aspect of the Research Question they Address



Qualitative and quantitative research methods were combined, and were integrated at the data collection and data analysis stages (see below for a discussion of mixed methods research). The selection of research methods inevitably involved a trade-off between the validity, feasibility, acceptability and cost of different methods available; those selected were the most appropriate for the study design and for exploratory research. Future research to test the hypotheses resulting from this study should employ research methods appropriate for hypothesis-testing and more rigorous statistical analysis.

Preparation to Conduct Research

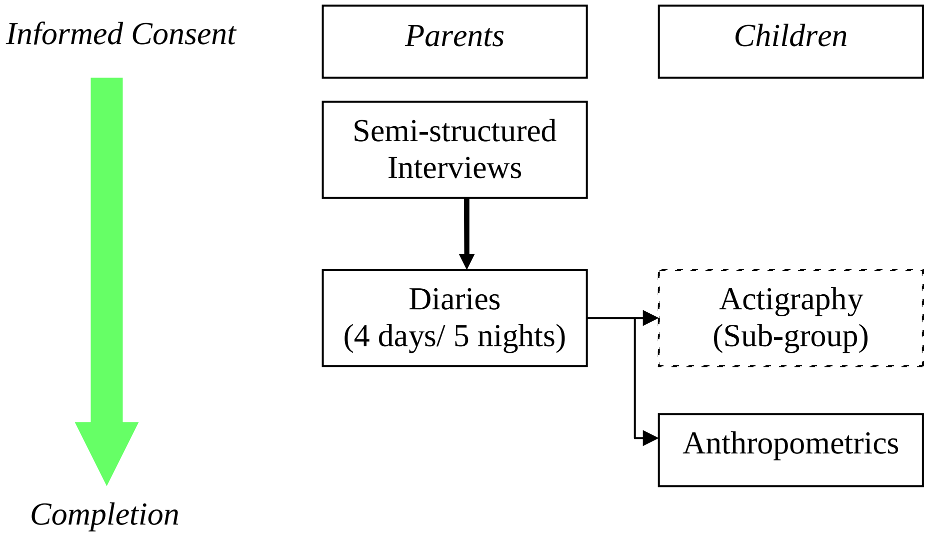
I conducted each stage of the research in its entirety, from recruitment to data collection and analysis; no additional research assistants were involved. I conducted pilot work in summer 2007 so that I was fully competent and confident in each method. I interviewed five mothers, and confirmed that I was able to build and maintain a good level of rapport, follow the interview plan, obtain an appropriate level of detail, and identify interesting responses. I asked two parents to complete a diary; on the basis of their entries and verbal feedback I refined its content and layout. I was trained in anthropometric measuring by senior lecturer in anthropology and health and human sciences, Dr Tessa Pollard, and practiced taking measurements, including with a 3-year-old child. My measurements were compared with those of a researcher who was experienced in these techniques, and a good level of agreement was consistently achieved. I was also trained in actigraphy: I practiced collecting and downloading actigraphy data from myself and other people, including a 3-year-old child. Piloting each of the methods with children aged 3 years and with parents of 3-year-old children, all in Stockton-on-Tees, confirmed that the methods were appropriate for the study population, and that compliance could be gained from children of this age and their parents.

Timeline of Methods

Once I had received written consent for a nursery to participate, and a convenient time had been arranged, then I attended the nursery each day for a period of 1-2 months. I became immersed in daily activities, for example assisting the staff and spending time with the children (see above). This helped me to become familiar with the staff, children and parents, and for them to become comfortable with me. I spoke to parents as they brought their children to nursery and collected them, which further helped in gaining their trust and building rapport.

Once I had been at each nursery for around 1-2 weeks, I began to ask parents if they would like to participate in the study. The research methods used and their ordering are shown in Figure 4.4. All parents who participated began by being interviewed. At the end of each interview, parents were given a diary to complete for 4 days and 5 nights. At some point over the following week, children's anthropometric measurements were taken. A sub-group of children participated in the actigraphy phase of the study: they wore actiwatches for the same period that their parents completed the diary. I conducted each stage of the research on nursery school premises. For each family, the process took between 1 to 2 weeks to complete. (Note that parents who had multiple children were asked to refer to their 3-year-old child specifically during interviews, and to only document the sleep, activities and food intake of their 3-year-old child in the diaries.)

Figure 4.4: Timeline of Research Methods



Interviews

Upon providing informed consent, parents were interviewed regarding a typical day and week for them and their child. The focus of interviews was parents' attitudes and practices regarding their child's sleep, diet and activities, and approaches towards parenting in general.

Interviews were arranged to take place at a time convenient for each participant (usually whilst children were at nursery, but sometimes at lunch time). They lasted between 40-90 minutes each, according to the length of participant responses. They were conducted in a private room in each nursery school. Only the consenting parent and I were present at each interview, unless the parent had brought someone else with them whom they were happy to attend, for example another child, or a partner.

I had begun to build rapport with parents prior to interviewing them, by attending the nursery each day. Interviews were relaxed and informal; interviewing style was sensitive, clear and gentle, following the criteria of a successful interviewer (Kvale, 1996). Supportive listening was followed, whereby I maintained eye contact and confirmed my understanding of participants' comments verbally and visually (Dickson-Swift et al., 2007).

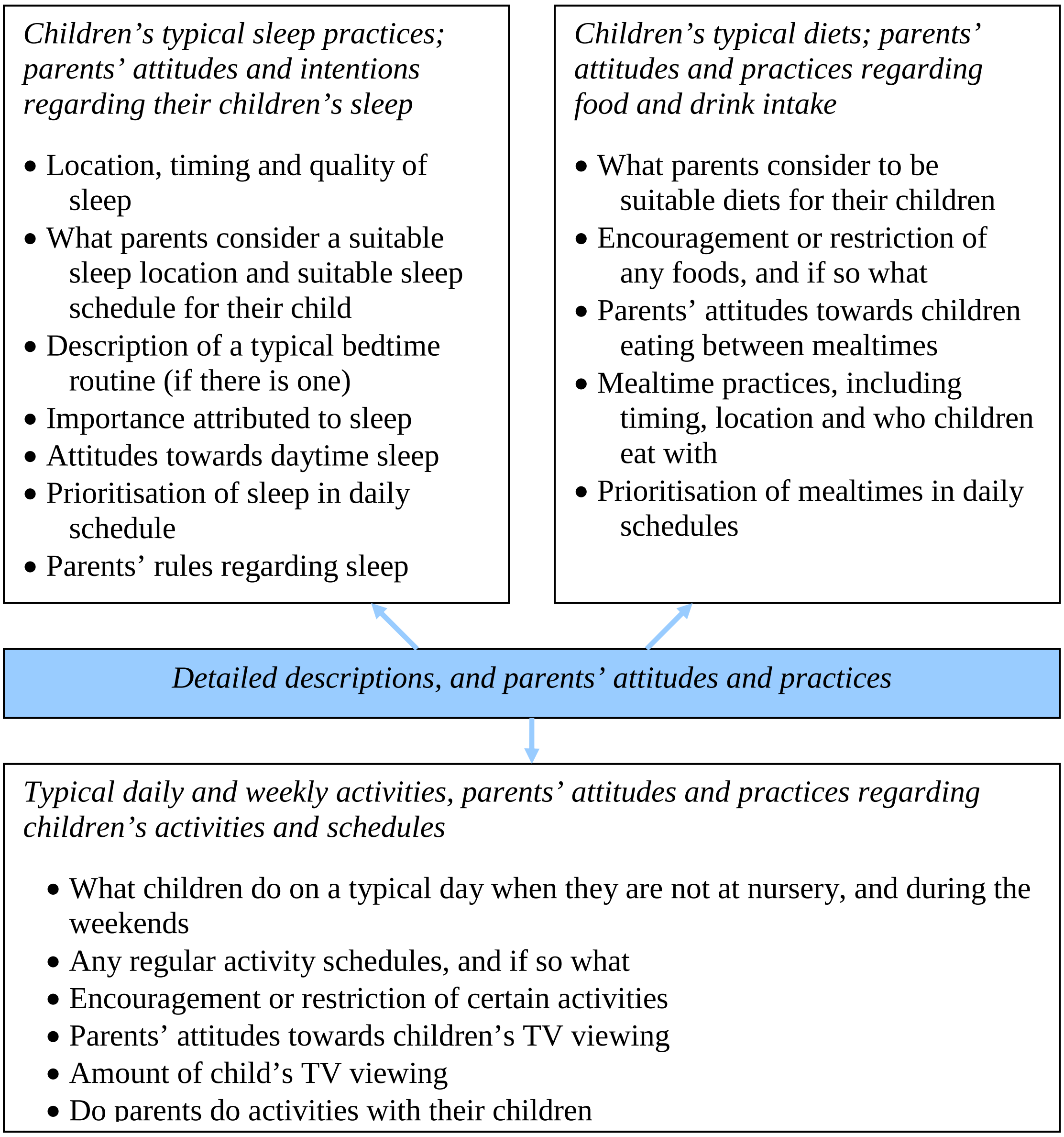
Interviews were semi-structured; a list of topics and questions was prepared in advance (see Appendix E: Interview Guide), but the precise content and wording were flexible, and there was the possibility to expand on additional topics raised during interviews and to ask further questions in response to interesting replies. Although the wording was not defined for each question, I asked all questions in a non-leading manner. Questions were open-ended where possible to allow parents to format their own responses. There were no preconceived hypotheses to be tested in interviews, and so semi-structured interviews and open-ended questions allowed parents to provide unanticipated responses and to spontaneously offer topics which were perceived as important by them rather than by me. The topics which I typically asked about during interviews are shown in Figure 4.5.

Since sleep, obesity and parenting vary with social and demographic factors (see Chapter 3), relevant information was also obtained during interviews, including family composition, children's birth order and number of siblings; children's and parents' dates of birth; children's ethnicity and health status; parents' employment status; and the number of people and rooms in the house.

Background information was also obtained regarding other factors which are known to influence 1) children's sleep (including whether children sleep in their own bedroom or a shared bedroom, 2) children's risk of obesity (including birthweight and duration of breastfeeding), or 3) both (whether their child has a TV in their bedroom) (see Chapter 3). In order to assess the presence of children's sleep problems, parents were asked whether they think their child has a problem with sleep onset or night wakings.

A significant risk factor for obesity in children, which was not measured in this study, is parental obesity (Reilly et al., 2005; Parsons et al., 1999). Although assessment of parents' weight and obesity status may have strengthened the quantitative component of this investigation, I did not feel that it was appropriate to ask parents to report their weight and height. It is sensitive information and I did not want to upset the interviewer-interviewee relationship, or for parents to feel uncomfortable. Furthermore, body weight is often underestimated by adults; for example, a review of 34 studies including women's self-reported weight found that in all 34, women underestimated their weight (Engstrom et al., 2003). Therefore, asking parents to self-report their weight and height may have resulted in inaccurate measures and inaccurate classifications of obesity status. This was an exploratory study and so controlling for parental obesity in statistical analyses was not crucial; however, including this significant childhood obesity risk factor could strengthen future research into this topic.

Figure 4.5: Topics Discussed in Semi-Structured Interviews



Interviews were digitally recorded on a portable Sony® IC Recorder. Despite the possibility that interviewees may not speak as freely when being tape recorded (Parker, 2000), there are advantages to recording interviews: the natural limitations of memory and intuitive glosses are corrected; investigation of interviews can be more through; and the data obtained can be reused in the light of new theoretical strategies (Heritage, 1984). Digital recordings were required for the data analysis stage, to categorise participant responses once themes had been identified (see below). Written notes were also taken during interviews, which are valuable additions to recordings (Bernard, 2002).

Limitations of interviews include interviewer effects, whereby participants' responses are influenced by characteristics of the interviewer such as age, gender, ethnicity and social background (Katz, 1942; Schuman & Converse, 1971; Shuman & Presser, 1981). Also, social desirability reporting can cause interviewees to report what is considered desirable rather than what is their reality. In order to limit the risk of social desirability bias, I became familiar to parents and built rapport by attending each nursery for at least 1-2 weeks before interviews took place, gained the support and recommendation of trusted nursery staff, and was non-judgemental towards interviewees (Bryman, 2004).

The semi-structured interview design was more appropriate than an unstructured interview style because it enabled me to address the same set of topics with all of the participants, to identify common responses, and to compare responses between participants. It was also more appropriate than a structured interview style (in which the same questions are asked in the same order to all participants), because more general questions associated with the semi-structured design allowed participants to describe their attitudes and opinions in their own words, and to discuss what they perceived to be relevant regarding their children's sleep, diet and activities. Focus groups were another method that I could have employed, to interview several participants together and explore how parents discuss the topics as members of a group. I did not feel that this method was appropriate for the exploration of parents' attitudes and behaviours: I was concerned that the reaching of a group consensus would mask individual variation in attitudes; participants would be more prone to expressing socially desirable views when in a group; and the topics of parenting and parent-child relationships could be personal and cause parents discomfort in group discussions (Bryman, 2004).

The focus of interviews was parents' attitudes, intentions and approaches to parenting, for which interviewing was the most appropriate method. Interviews enabled parents to discuss unusual behaviours which would not have been well assessed by quantitative methods (Beebe et al., 2006); however, interviewees are likely to misreport behaviours, for example being unable to accurately remember behaviours and their frequency (Bernard, 2002). Combining interviews with diary data helped to overcome any limitations in assessing children's behaviours: the interviews provided a detailed description of the reasons for parents' practices and the intentions behind their behaviours, whilst children's sleep, food intake and activities themselves were assessed quantitatively with diaries.

Diaries

At the end of each interview, I gave parents a diary in which to document their children's sleep, food intake and activities for 4 days and 5 nights (see Appendix F: Diary). I showed the diary to parents, instructed them on how to complete it, and gave them the opportunity to ask any questions about how to fill it in.

Parents were assigned 2 week days and 2 weekend days (3 week nights and 2 weekend nights) to complete the diary; a combination of week and weekend days/ nights was important since schedules can vary across these days even in children as young as 3-years-old (Chapter 2). Diaries were intended to document typical days (not holidays, special events, or when children were ill). The next consecutive 4 days/5 nights (including 2 weekend days/ nights) following the interview were selected for parents to complete the diary, unless these were not typical days. If children were on holiday or attending special events, were poorly, or these days were not representative of typical days for any other reason, then the diary was delayed, and the next available consecutive typical 4 day/5 night period was selected. Parents were instructed that if their children became ill during the diary period then they should stop filling in the diary, and resume it once they were well again.

Since I attended nursery each day, parents had the opportunity to ask any questions and to ask for clarification as they completed the diary. I was also able to remind parents each day to fill it in, and to ask them if they were happy with what to do. Once the diaries were completed, parents returned them to me at the nursery. Instructing parents on how to complete the diary at the end of each interview, and providing an opportunity to ask questions each day helped to limit the risk that questions would be misinterpreted or ignored, which is problematic when responses to the same questions are compared between participants (Sobo & De Munck, 1998). Being at the nursery every day to remind parents to fill in and then return the diaries also minimised the risk that parents would forget, or fail to return them.

Figure 4.6 shows the information which parents were asked to document in the diaries. Parental reporting suffers the possibility of recall bias; in order to minimise this risk, parents were asked to document their children's food intake and activities throughout the day as they occurred and to enter sleep information as soon as their children were asleep.

Figure 4.6: Information Documented in the Diaries

SLEEP

- Times at which children got into bed, went to sleep, woke up for the day, and got out of bed for the day
- Timing and duration of night wakings
- Locations of sleep onset and sleep throughout the night (including any changes in sleep location)
- Timing and location of daytime sleep periods

Details of all occurrences of sleep, food and drink intake & relevant activities

FOOD & DRINK CONSUMED

- All foods and drinks consumed by children, including during mealtimes and for snacks
- A brief description of each food and drink and their quantity
- Time of consumption

ACTIVITIES

- Periods of active play, walking, and other physical activities
- Television viewing and computer use
- Time at which these activities began, and their duration

All children attended the nursery from which they were recruited for either a morning or afternoon session each week day. Parents were not required to complete the diary for periods when their children were at nursery, because a) they would be unable to accurately report their children's behaviours during these periods, and b) sleep, food intake and activities were similar for all children during these periods: all children were prevented from sleeping at nursery, all children were offered milk and one piece of fruit per day, and all children spent the same amount of time in physical activity.

If children attended other nurseries additionally to the one from which they were recruited (for example a private nursery for the rest of the day), then parents were instructed to ask the nursery staff for the relevant information so that they could complete the diary. Similarly, if children spent time being cared for by other people (for example grandparents), parents were asked to obtain the relevant information and complete the diary for these periods, or to instruct other caregivers on how to complete the diary on their behalf.

Parental reports of children's sleep, eating and activity have been implemented successfully in previous studies investigating child obesity risk factors (for example Agras et al., 2004; Sekine et al., 2002b; Von Kries et al., 2002). Regarding the sleep section, comparisons between actigraphy and daily parental reports indicate that parents are accurate reporters of children's sleep-wake schedules (Titotzky & Sadeh, 2001; Sekine et al., 2002a). Although parents have been demonstrated to less accurately report children's sleep quality and night wakings (Tikotzky & Sadeh, 2001), the focus of this study was sleep duration rather than quality (see Chapter 2). Parents may overestimate their children's sleep duration by reporting bed and rise times rather than sleep and wake times (Sekine et al., 2002a): in this study, including the times that children got into and out of bed in addition to sleep and wake up times in the diaries limited the risk that parents would misinterpret sleep and wake questions. Parents were clearly instructed to document the time at which their children went to sleep, even if this was before they got into bed.

The sleep section of the diaries was validated against actigraphy in a subgroup of children (see below). Other methods to assess sleep include polysomnography: this is the gold-standard for sleep measurement, but it was impractical for this study due to the cost constraints and specialist training required. Furthermore, its requirement to be conducted in a laboratory, with monitoring being moderately obtrusive and bedtimes being stipulated by examiners, suggests that diaries and actigraphy may be better indicators of typical sleep habits in children (Beebe et al., 2006). Similarly to polysomnography, video monitoring of children's sleep (either in the participant's home or in the University Sleep Laboratory) would have excluded daytime naps, which are a focus of this study (see Chapter 2). Further limitations of video monitoring include that the data analysis is time consuming and requires the researcher to judge when the participant is asleep, which can be difficult when there is not a clear view of the participant's face and when the participant is lying awake but still with eyes shut.

Actigraphy and diary report are less obtrusive methods compared to polysomnography and video monitoring, are able to assess sleep over extended periods (including both daytime and nighttime), and are cost-effective and simple to complete. Actigraphy is favourably validated against polysomnography, and so was appropriate for use in a subgroup of children in this study in order to validate the diaries and assess the accuracy of parental reporting (see below). Diaries, validated by actigraphy, were therefore the most appropriate method for assessing children's sleep patterns for this study. These methods improved on those used in previous studies into the sleep-obesity link (see Chapter 2): the parent report measure was validated by an objective measure, was used over an extended period of time (rather than a single question), clearly asked for sleep and wake times (rather than bed and rise times), and included week and weekend measures of sleep, and daytime in addition to nighttime sleep. The sleep section of the diaries was validated by an objective measure (actigraphy) because sleep was the main focus of the investigation; similar validation of the other sections of the diary (food intake and activities) was not carried out because these variables were not the primary focus of the study, and diary record was appropriate for the exploratory design.

Regarding the diet section of the diary, assessing food intake in preschool children by parental record is an established method for the recording of food and drinks consumed during a specified time period (Serdula et al., 2001). Atkin & Davies (2000) similarly used a period of 4 consecutive days including a Saturday and a Sunday to assess diet composition in preschool children. Although preschool children's food consumption is highly variable from meal to meal, daily energy intake is relatively constant: Birch et al. (1991) found that for most preschoolers they studied, high energy intake at one meal was followed by low energy intake at the next. Since intake remains relatively stable across days, assessing food intake over 4 days overcomes meal-to-meal variation, in order to assess habitual daily food intake.

Other methods which could have been employed for assessing food intake are food frequency questionnaires and 24-hour food recalls, which enable more accurate estimates of nutritional intake. Nutritional intake could also have been more accurately assessed using the diaries if parents had been asked to weigh and measure the portions served to their children and any foods left over. However, this would have been intensive for participants and would likely have lowered the return rate of the diaries. Besides, nutritional intake cannot be measured with absolute precision in free-living populations using any method, and much of the dietary data on children is prone to reporting error (Livingston et al., 2004). For the purposes of this investigation, the diet section of the diaries aimed to examine the types of foods habitually consumed by children, rather than precise nutritional content. For this purpose, dietary record is appropriate. Advantages of the food diary included that information was recorded at consumption, preventing recall bias or items being forgotten (Serdula et al., 2001); this is particularly important for preschool children, who eat small amounts of food at frequent intervals. Parents were able to record any food items, rather than being restricted to pre-determined items in a list. Furthermore, food diaries could be combined with the sleep and activity sections to form a single diary, thereby reducing the number of items given to parents, and minimising parental effort required.

Diary record was also appropriate for estimating children's physical and sedentary activities. Epstein et al. (2004) similarly used 4 day diaries with parents of school children (and children themselves) to document all of the children's activities, including physical activities and TV viewing. Comparisons with activity monitors showed that energy expenditures calculated from activity monitors and diary reports were substantially correlated, leading the authors to conclude that 4 day diary records are appropriate for assessing children's physical activities and TV viewing.

Regarding physical activity in particular, research has found that parent-reported measures of outdoor playtime in preschool children are significantly correlated to direct measures of physical activity, leading the authors to suggest that parent-report of outdoor playtime may be a surrogate measure of physical activity in preschoolers (Burdette et al., 2004). Accordingly, in this study, parents were explicitly asked to document physical and outdoor playtime in the diaries. An alternative method for assessing physical activity would have been activity monitors: however, this would not have provided information regarding the specific activities being undertaken. It is also more costly than parent-report, and it was not possible to obtain accelerometers for this study (different activity monitors would have been needed in addition to the actiwatches, since physical activity is best assessed by accelerometers worn on the waist). Direct observation by researchers is another method for objective assessment of physical activity; however, this would not have been possible for 4 days, would have been time-consuming and labour-intensive and was out of the scope of this study.

Regarding TV viewing, parentally-completed diaries have been shown to correlate well with video observation of time preschool children spend watching TV, with very small absolute mean error times (Anderson et al., 1985). Therefore, parental diary report is an appropriate method for assessing preschool children's TV viewing.

Overall, parentally-completed diaries were appropriate for assessing children's sleep-wake patterns, food intake, physical activity and TV viewing in this study. Although other methods may have been able to measure each of these categories with increased accuracy, diary report was appropriate for the research aims and the study design. Diary report enabled all of the behaviours (sleep, food intake and activities) to be recorded in one document, which was more convenient and less intensive for participants. Each of the behaviours was measured over the same time period, which enabled correlations to be assessed between children's concurrent sleep, food intake and activities. A length of 4 days and 5 nights has been used in previous studies assessing these variables, and is an improvement on the majority of sleep-obesity studies.

Actigraphy

A subgroup of children participated in actigraphy, which was used to validate the sleep section of the diaries. Actiwatches are small watch-like devices which monitor movement, and on the basis of duration and intensity of movement predict at which periods the wearer was asleep. Actigraphy data is analysed using a scoring analysis programme, whereby an algorithm is used to translate activity data into sleep-wake patterns (Sadeh et al., 1989, 1991, 1994).

Actigraphy was the method chosen to validate the diaries since it is able to measure sleep over extended periods (including daytime as well as nighttime), is not burdensome for participants, and is cost-effective. This method has been validated to monitor sleep-wake patterns with a high degree of accuracy (Jean-Louis et al., 1999; Shinkoda et al., 1998); the algorithm identifies at what points the participant is awake and asleep with high reliability, in 80-90% agreement with the gold-standard objective sleep measure, whole-night polysomnography (Tzischinksy & Latzer, 2006). Actigraphy has been favourably validated against polysomnography for use in sleep studies with young children in particular (Kushida et al., 2001), and has been used in children as young as 3-years-old (Reilly et al., 2003a; So et al., 2005). The Actiwatch® Mini was selected for this study: it is ultra light-weight and suitable for use in young children.

Since the aim of actigraphy was to validate the sleep section of the diaries, participation of a sub-group rather than the whole sample was appropriate. Limited availability of actiwatches determined the size of the subgroup (there was one actiwatch available at the start of the data collection period, and an additional two became available for use part way through the data collection year). According to whether there was an actiwatch currently available, at the end of an interview I showed parents the actiwatch, explained its purpose, and asked whether they would like their children to participate in the actigraphy phase. When parents consented, I showed the actiwatch to their child and explained that it was a special watch to measure their sleep. I offered them a sticker with the SHINY study logo on it for each night that they kept it on[1]. If children were happy to wear it, they did so for the same period that their diary was completed. A period of 5 nights such as this has been established to ensure reliability (Acebo et al., 1999). Parents and children were instructed that the actiwatch should be worn for the whole period, including during the daytime, so that total sleep duration throughout each day could be estimated. Parents were asked to document any times at which it was taken off (although this was not necessary, since it is fully waterproof).

[1] Attending each nursery daily for a period of 1-2 months helped me to establish and maintain good relationships with participants, which I believe strengthened my data. My familiarity to parents and children, and recommendation from nursery staff, were beneficial in encouraging participation. Seeing the children every day allowed me to encourage those participating in the actigraphy phase to keep the actiwatch on, and to reward them with a sticker each day. Being familiar to the children also helped me to gain their trust and compliance in being measured. I was also able to effectively build rapport with parents before commencing interviewing, which may have led to improved data. By visiting each nursery every day, I was able to remind parents to fill in the diary on the relevant days, and to answer any questions, resulting in more complete diary data and a higher return rate compared to if I had not attended each day.

Once the actiwatch was returned at the end of the 4 day/5 night period, the data were downloaded immediately onto the software so that I could provide a summary of the results to parents. I explained the results verbally and also provided a written summary, which parents were invariable interested in and happy to receive. Further analyses of actigraphy data were performed at the end of the data collection process.

Anthropometrics

At the end of each interview, I described the anthropometric phase of the study, and asked parents if they would like to provide consent for their child to be measured. If they provided informed consent, and children agreed, then measuring took place later that week or the following week.

I took anthropometric measurements of the children myself, rather than asking parents to report their children's weight and height, so that any error resulting from different people taking measurements would be eliminated. This enabled more accurate weight categorisation, since overweight prevalence rates in preschool children are underestimated when weight and height are reported by parents: a study of Dutch 4-year-olds found that over 45% of overweight children according to researcher-measured BMI were missed when parent-reported BMI was used (Scholtens et al., 2007). Carrying out measurements myself also enabled me to include waist circumference and skinfold thickness in addition to weight and height.

Children were measured at nursery, in a quiet corner of the main room. They were measured in the presence of a familiar adult (a member of nursery staff or a parent), and multiple children were measured in one day so that they could participate together. The techniques were described to the children and they were able to ask questions. I demonstrated the calipers (for measuring skinfold thickness) on myself, and children were given the opportunity to have a practice measurement taken on their hand, to assure them that it is not painful. Only when the children were happy with the techniques and agreed to be measured did I measure them. They were offered a sticker displaying the SHINY study logo if they competed all of the measurements. The children were keen to receive a sticker: some children asked if they could be measured especially so that they could receive one[2].

The measurements taken to assess body composition were height and weight (so that BMI could be calculated), waist circumference, and subscapular and triceps skinfolds. Waist circumference and subscapular skinfold thickness assess central fat in particular. Other methods to measure body composition were ruled out for use in this study due to unsuitability for use with young children (for example underwater weighing), and availability and cost (for example bioelectrical impedance analysis, magnetic resonance imaging and dual-energy X-ray absorptiometry). The measurements selected for this study were suggested by Eisenmann et al. (2006) to be suitable and safe for use in this age group, and are cost-effective, non-invasive, and relatively simple to perform.

As described in Chapter 2, BMI is a widely used measure of obesity, which has been used to assess body composition and weight status in the vast majority of sleep-obesity studies. BMI can be converted to standardised scores, and used to categorise children as normal weight, overweight or obese. Some sleep-obesity studies have used the BMI cut off points specified by Cole et al. (2000) (for example Padez et al., 2009; Nixon et al., 2008), and standardised BMI scores have also been successfully implemented in sleep-obesity research, including in British children using UK reference data (Reilly et al., 2005; for UK reference data see Cole et al. 1990). This study similarly measured BMI to assign children to waist status categories, and used British reference data to convert raw values into SD scores (see below).

Chapter 2 described the importance of other, more direct measures of fat mass and abdominal obesity for health research, such as waist circumference and skinfold thickness; therefore these measures were used in this study. Regarding skinfold thickness, there are some potential reliability and accuracy problems: small differences in location of measurement can lead to different results, and compressibility of the skin and adipose tissue varies according to state of hydration, size of the participant, and between individuals (Lohman et al., 1988). Despite these limitations, skinfold thickness

[2] The same stickers were also a success in incentivising children to keep the actiwatch on. I believe that designing the SHINY study logo and associated materials helped me to improve the attractiveness of the study and to gain compliance with the children.

measures fat mass more sensitively than does BMI, and has been used in children as young as 3-years-old (Oken et al., 2007). (For a more comprehensive discussion of measures of obesity, see Chapter 2.)

Procedures for measuring height, weight, waist circumference and skinfold thickness were followed in accordance with the directions by Lohman et al. (1988). Children removed their shoes and heavy outer clothing. Height was measured to the nearest 0.1cm, using a stadiogram with a head bar, to align the head along the Frankfurt plane (Lohman et al., 1988). Electronic scales, placed on a hard surface, measured weight to the nearest 0.1kg. For waist circumference measurement, children lifted their t-shirts, and non-tearing inelastic measuring tape was placed flat, horizontally, at the narrowest part of the torso (typically between the lowest rib and the iliac crest bones); measurements were recorded to the nearest 0.1cm. Triceps and subscapular skinfolds were measured using Holtain calipers, to the nearest 0.1mm. For skinfold thickness, intra-measurer error values have been determined which dictate the maximum difference permitted between three measurements taken at each site in order for the results to be reliable (Lohman et al., 1988); if this error was exceeded, then I took an entirely new set of measurements for that participant at that site. In order to reduce intra-measurer error, three of each measurement was taken, and the average calculated (weight was taken only twice, since it was measured using a digital machine). I recorded measurements on a data sheet, on which participants were identified anonymously, using their participant number (see Appendix G: Anthropometric Data Sheet).

Mixed Methods Design

This study employed a mixed methods design, incorporating both qualitative methods (interviews) and quantitative methods (diaries, actigraphy, anthropometrics). Each method was the most appropriate for the aspect of the research question which it was applied to; therefore a combination of qualitative and quantitative research methods was most appropriate for exploring the topic as a whole.

Using qualitative and quantitative methods to examine different aspects of the overall research question is a useful technique for mixed methods research (O’Cathain et al., 2010). Health researchers are increasing using mixed methods research designs, since they have the ability to generate new insights (Lingard et al., 2008). In this study, methods were integrated during data collection and analysis. Qualitative methods were used first, but qualitative and quantitative methods were prioritised equally.

Mixing methods can overcome the limitations of individual methods, and each method can contribute to the other (Barbour, 1999). In this study, qualitative data contributed to quantitative data by providing explanations for behaviours and indentifying attitudes and practices to be studied quantitatively; quantitative data contributed to qualitative data by enabling statistical analyses, and providing quantitative measures of behaviours to compare across qualitative descriptions. Hence both approaches were enhanced by inclusion of the other, and contributed to the generation of ideas that would not have been possible with a single approach. The overall research design offered the strength of confirmatory statistical results from quantitative analyses, along with detailed and explanatory descriptions from qualitative analyses (Castro et al., 2010).

Some researchers argue that because qualitative and quantitative research methods derive from different traditions, with different approaches and values, their integration is impossible (Kuhn, 1970). However, there is agreement amongst others that they are not absolute nor mutually exclusive (Morgan et al., 2007). I aimed in this study to demonstrate that the integration of qualitative and quantitative techniques is not only possible, but enhances knowledge generation.

Summary: Research Methods

The research methods used were semi-structured interviews and 4 day/5 night diaries with parents, and anthropometric measurements with children. A subgroup of children participated in actigraphy, in order to validate the sleep section of the diaries. These different methods (including a mixture of quantitative and qualitative) were selected to explore different aspects of the research topic according to their appropriateness, ability to investigate the topic, validity, feasibility and acceptability. Qualitative methods (interviews) investigated parents' attitudes and practices regarding their children's sleep, food intake and activities, and general approaches to parenting; and quantitative methods assessed children's sleep, food intake, physical activity and TV viewing over a typical 4 day/5 night period (diaries), and children's body composition (anthropometric measurements). Demographic information was also obtained during interviews.

Data Analysis

This section of the chapter will describe the analysis of the data. Upon consenting to participate, families were assigned a participant number. I created a database in Microsoft Office Excel 2003 and all data referring to each participant was entered into the database under their participant number. The area in which their nursery was located (affluent or deprived) was listed in the database, and there were separate spreadsheets for interview, diary, anthropometric and actigraphy data.

Preparation of Diary Data

I entered raw data from the diaries into the spreadsheet, and performed calculations in Microsoft Office Excel. Weekdays were considered Monday-Friday (inclusive), and week nights were considered Sunday-Thursday nights. Weekend days were considered Saturday-Sunday, and weekend nights were considered Friday- Saturday nights.

a) Sleep

For each child, nighttime sleep duration for each night was calculated by subtracting sleep start time from wake up time. Sleep onset latency was calculated for each night by subtracting the time children got into bed from sleep start time. Since sleep onset time assumes that children fell asleep in bed, where children fell asleep outside of bed and were taken to bed once they were asleep, I did not calculate sleep onset latency. Where children fell asleep on the sofa at least one night, this was documented in the spreadsheet.

Separate means were calculated for each child for week and weekend nights for bedtime, sleep start time, wake up time, get up (rise) time, sleep onset latency (except for children who did not fall asleep in a bed every night), and nighttime sleep duration. The amount of time that children slept during the day (napping) was totalled for each day. Weekday and weekend day means were calculated for nap duration; these were combined with week night and weekend night mean sleep durations respectively, to produce mean total daily sleep durations (per 24 hours) for week and weekend periods.

The range between the earliest and latest documented bedtime for each child was calculated by subtracting the earliest bedtime from the latest bedtime. The duration of night wakings was totalled per night for each child. If there were no night wakings then the duration was entered as 0 minutes.

b) Food Intake

Foods were grouped for analysis. Food groups were created prior to data collection and analysis, in consultation with professor of human nutrition, Carolyn Summerbell. Food groups were chosen and created which are associated with risk of obesity, since risk of obesity was the focus of the diet section of this study (see Chapter 3): these were fruit and vegetables (negatively associated with risk of obesity), and pre-prepared foods and sweets (positively associated with risk of obesity). The foods included in each group are shown in Table 4.2.

Table 4.2: Food Groups and the Foods Included in Each Group

Food Group	Foods included
Fruit & Vegetables	Fruit Salad Vegetables
Pre-Prepared Foods	Crisps Chips Fish Fingers Chicken Nuggets Pastries Pies Pizza Sausage Rolls Fast Food
Sweets	Biscuits Sweets Cakes Lollies Tart Chocolate

Since consumption of carbonated drinks is also associated with risk of obesity, whether children consumed any carbonated drinks or not was entered into the spreadsheet (categorised as at least one carbonated drink documented in the diary versus no carbonated drinks documented).

Grouping foods into broad categories in this manner is a technique undertaken by nutritionists, and similar groups to the ones I created have been used in previous research. For example, a combined fruit and vegetable group has been used in analyses of weight gain (Sammel et al., 2003; Halkjaer et al., 2004). I included all kinds of fruit and fresh vegetables in this group, in accordance with Schulz et al.'s (2002) categories; chips and fruit juice were not included (consistent with the categories used by Field et al., 2003).

Combining sweet foods into a single category is consistent with studies by Sammel et al. (2003) (whose "sweets" category included desserts and candy); Halkjaer et al. (2004) (who had a cakes and chocolate category); and Parker et al. (1997) (who designed a combined "sweet" category). In North et al.'s (2000) study of preschoolers, consumption of the following food types were correlated together: chips, burgers, pies, pastries, crisps, takeaway meals, and pizza. I combined these foods into a pre-prepared category, and included other high fat, pre-prepared foods. Other studies have similarly included food groups based on foods high in fat (for example Sammel et al., 2003).

For each of the food groups, the number of servings of foods in that group was totalled for each child for each day. All servings of the relevant foods were included; if the same food was entered multiple times in a day then these were considered separate servings. Within a single serving, no account was taken of the quantity of food, the size of the serving, or the amount of food that was left over by children. Examination of the nutritional content of the foods consumed was out of the scope of this study; of interest were the types of foods commonly consumed by children, and any variation in the types of foods different children received.

For each child, the mean daily number of servings for each food group was calculated. Some parents described their children eating treats or special foods at weekends, and this sometimes included Friday evenings. It was therefore not appropriate to calculate separate means for week and weekend days, since such food consumed on Friday evenings would be incorrectly assigned to weekday servings. It was not possible to determine cut off points on Friday evenings to allocate foods to week or weekend categories, hence means across all 4 days were calculated, rather than separate week and weekend means. Since all parents completed the diary for 2 week and 2 weekend days, any discrepancies between week and weekend food intake is expected to be consistent between children.

Parents were not asked to specify whether foods were served at mealtimes or as snacks in the diaries; rather they listed all food and drinks consumed, and timing of consumption. Where mealtimes were obvious in the diaries (by judging the amount, combination and timing of foods served), then the time of the evening meal was entered into the spreadsheet. Mean time of consumption of the evening meal was calculated for week days and weekend days. Where distinct mealtimes were not obvious (for example small amounts of food were documented in the diary frequently throughout the day, and there were no distinct meals) then this was noted in the spreadsheet. A particular note was made when there was at least one day where no obvious breakfast was documented.

c) Activities

Time spent in each of the physical activities specified in the diaries (active play and walking) was totalled for each day for each child. Time children spent shopping was included in the walking category, since children were assumed to have been walking at the shops (I observed that the majority of children walked to nursery; and no parents discussed the regular use of buggies during interviews). Additional activities which were assumed to be physically active (such as dancing, football, biking, going to the park) were totalled as a separate physical activities category. Weekday and weekend day means were calculated for the time spent in each of the physical activities (active play, walking, additional physical activities). Daily durations of each of these were also totalled, and weekday and weekend day means were calculated for overall physical activity.

Time spent watching TV and using a computer were totalled for each child for each day, and weekday and weekend day means were calculated. Where TV viewing was documented as co-occurring with another activity (for example parents entered “TV” and “jigsaw” as occurring at the same time), or where parents wrote in the diary that the TV was on in the background, then it was included in total daily TV viewing duration.

The latest time at which each child stopped watching TV each day was calculated by adding the duration of the day’s last documented TV viewing to the time at which it began (for example, if the last time a child watched TV for the day was at 18:00, for 30 minutes, then their end TV viewing time for that day was 18:30). For each participant, the latest TV viewing times for all 4 days were examined, and the latest of these times was identified, resulting in an overall latest TV viewing time variable for each child.

Preparation of Actigraphy Data

Actiwatch data were downloaded into the software according to the user manual. For each night that the actiwatch was worn, the times at which children got into bed and got up for the day were entered into the software (as documented in the diaries). Where no bedtime was reported in the diary, or the diary indicated that children fell asleep prior to getting into bed, then a ‘false’ bedtime of 18:00 was entered into the software. A time of 18:00 was selected because it was earlier than the earliest bedtime reported in all of the diaries. Similarly, where the time at which children got out of bed was not reported then a ‘false’ get up time of 09:00 was entered, which was later than the sample mean get up time, and late enough for wake up time to be calculated. The algorithm calculated nighttime sleep-wake variables: these included sleep start time, wake up time, number of wakes after sleep onset, and sleep efficiency. Of interest were sleep start and wake up times, for direct comparison with diary estimates of sleep and wake up times. Actigraphy scores of sleep efficiency were not examined since sleep quantity, rather than quality, has a more robust association with children’s risk of obesity, and was the focus of this investigation (Chapter 2).

The actigraphy software has a nap analysis programme: in order to assess children’s daily nap durations, rise times and bedtimes were entered again into this analysis programme. The algorithm estimated the duration that children were asleep during the day after they had got out of bed in the morning, and before they went to bed in the evening, for comparison with diary estimates of daytime nap duration.

For each participant I examined the actigraphy- and diary-derived sleep onset times, wake up times and daily nap durations to check for discrepancies: if large discrepancies had been found then I would have had the opportunity to ask parents for clarification (however this was not necessary because no large discrepancies were identified).

Preparation of Anthropometric Data

Means were calculated for each child for height, weight, waist circumference, and triceps and subscapular skinfold thicknesses. BMI was calculated using the equation weight/height^2 (kg/m^2). Children were categorised as being ideal weight, overweight or obese, according to BMI cut-off values for overweight and obesity specific for sex and 6-month age bands, which are widely used in obesity research (Cole et al., 2000).

SD scores were calculated for BMI and waist circumference using British 1990 reference data (Cole et al., 1990), and for triceps and subscapular skinfold thicknesses using WHO 2006 reference data (WHO, 2006). The British reference dataset was used in the ALSPAC study (Reilly et al., 2005); British reference data was not available for skinfold thickness, and so international reference data were used.

Although measures of skinfold thickness can be converted into estimates of body fat percentage (Law et al., 1992), this estimate is based on skinfold measurements at just two sites, and it does not take into consideration ethnic, gender and other differences in body composition (Duncan et al., 2004). Therefore for this study, direct measures of skinfold thickness were used, rather than derived estimates of body fat percentage.

Table 4.3 summarises the variables which were derived from the diaries, actigraphy and anthropometrics.

Table 4.3: Diary, Actigraphy and Anthropometric Variables which were Derived for Analyses

Variable		Type of Data	How it was Derived (continuous), or Codes (categorical)
Diary: Sleep	Bedtime	Week and weekend means	Time at which child got into bed (hh:mm)
	Range in bedtimes	Single value across all days	Latest bedtime of all days minus earliest bedtime of all days (mins)
	Sleep start time	Week and weekend means	Time at which child fell asleep for the night (hh:mm)
	Sleep onset time (for comparison with actigraphy)	Mean of all nights, and for third night only	Time at which child fell asleep for the night (hh:mm) (only for children who completed actigraphy)
	Wake up time	Week and weekend means	Time at which child woke up for the day (hh:mm)
	Wake up time (for comparison with actigraphy)	Mean of all nights, and for third night only	Time at which child woke up for the day (hh:mm) (only for children who completed actigraphy)
	Get up time	Week and weekend means	Time at which child got out of bed for the day (hh:mm)
	Sleep onset latency	Week and weekend means	Sleep start time minus bedtime (mins) (excludes children who fell asleep before getting into bed)
	Nighttime sleep duration	Week and weekend means	Wake up time minus sleep start time (hh:mm)
	Daily nap duration	Week and weekend means	Total duration of all naps per day (mins) (for whole sample, and for nappers only)
	Daily nap duration (for comparison with actigraphy)	Mean of all days	Total duration of all naps per day (mins) (only for children who completed actigraphy)
	Location of naps	Categorical	Bedroom, buggy, car, living room
	Total daily sleep duration	Week and weekend means	Nighttime sleep duration plus daily nap duration (hh:mm)
	Duration of night wakings	Mean of all days	Total duration of all night wakings per night (mins) (for whole sample, and for children who woke only)
	Sleep onset location	Categorical	Own bed, parents' bed, sofa, another house
	Falling asleep on the sofa	Categorical	Sleep onset location was the sofa for at least one night, or for no nights
Diary: Food Intake	Daily servings of fruit & vegetables	Daily mean	Total number of servings of fruit and vegetables per day
	Daily servings of pre-prepared	Daily mean	Total number of servings of pre-prepared foods per day
	Daily servings of sweets	Daily mean	Total number of servings of sweets per day
	Consumption of carbonated drinks	Categorical	Child consumed at least one carbonated drink over the diary period, or no carbonated drinks
	Time of the evening meal	Week and weekend mean	Time at which the evening meal was consumed (hh:mm)
	3 distinct meals each day	Categorical	Child consumed 3 distinct meals each day, or did not

Table 4.3 continued

Variable		Type of Data	How it was Derived (continuous), or Codes (categorical)
Diary: Activities	Active play	Week and weekend means	Total duration of all episodes listed as active play per day (mins)
	Walking	Week and weekend means	Total duration of all episodes listed as walking or shopping per day (mins)
	Physical activities	Week and weekend means	Total duration of all episodes of other activities deemed to be physically active per day (including swimming, dancing, football) (mins)
	Total physical activity	Week and weekend means	Combined total duration of active play, walking, physical activities per day (mins)
	Computer use	Week and weekend means	Total duration of all episodes listed as computer per day (mins)
	TV viewing	Week and weekend means	Total duration of all episodes listed as watching TV per day (mins)
	Latest TV viewing time	Single value across all days	Latest time at which child stopped watching TV of all days (latest TV viewing episode plus duration) (hh:mm)
Actigraphy	Sleep onset time	Mean of all nights, and for third night only	Time at which child fell asleep for the night (hh:mm)
	Wake up time	Mean of all nights, and for third night only	Time at which child woke up for the day (hh:mm)
	Daily nap duration	Mean of all days	Total duration of all naps per day (mins)
Anthropometrics	Height	Mean of 3 measurements	Cm
	Weight	Mean of 2 measurements	Kg
	BMI	Single value	Mean weight/mean height2
	Weight status	Categorical	Ideal weight, overweight, obese (according to BMI cut-off values, Cole et al. 2000)
	Waist circumference	Mean of 3 measurements	Cm
	Triceps skinfold thickness	Mean of 3 measurements	Mm
	Subscapular skinfold thickness	Mean of 3 measurements	Mm
	BMI SD score	Calculated from mean	SD score using British 1990 reference data (Cole et al., 1990)
	Waist circumference SD score	Calculated from mean	SD score using British 1990 reference data (Cole et al., 1990)
	Triceps skinfold SD score	Calculated from mean	SD score using WHO 2006 reference data (WHO, 2006)
	Subscapular skinfold SD score	Calculated from mean	SD score using WHO 2006 reference data (WHO, 2006)

Preparation of Interview Data

Demographic information provided by parents during interviews was entered into the spreadsheet directly, or following basic calculations or categorisation: see Table 4.4 for the variables which were derived.

Table 4.4: Background Information Variables which were Derived from Interview Data

Variable		Type of Data	How it was Derived (continuous), or Codes (categorical)
Interviews: Background information	SES	Categorical	Affluent or deprived (according to the nursery from which family was recruited)
	Child's age	Continuous	Date of interview minus date of birth (months)
	Parent's age	Continuous	Date of interview minus date of birth (years)
	Child's gender	Categorical	Male or female
	Child's ethnicity	Categorical	White British or BME
	Family composition	Categorical	Both biological parents (plus grandparents), mother only (plus grandparents), mother and social father (plus grandparents)
	Child's birth order	Continuous	First born, second born, third born…
	Child's number of siblings	Continuous	None, 1, 2…
	Daylength on day of interview	Continuous	Sunset time minus sunrise time in Stockton-on-Tees (obtained from Royal Observatory Edinburgh)
	Child's birthweight	Categorical	Low (<5lb8oz), normal
	Child's breastfeeding duration	Categorical	Not at all, <1 month, 1 month or longer
	Mother's employment status	Categorical	Employed, not employed
	Father's employment status	Categorical	Employed, not employed
	Number of people per bedroom	Continuous	Number of people living in the house/ number of bedrooms
	Frequency of staying overnight in other households	Categorical	Less than monthly, once per month, once per fortnight, once or more per week

Information regarding children's sleep, diet and activities was coded into categorical variables according to participant responses. Regarding parents' attitudes and practices, during interviews and upon listening to the audio recordings, I identified themes which arose frequently and which were of particular interest. This process of generating themes by discovering which concepts are similarly discussed by participants when discussing a topic is termed grounded theory (Creswell, 2007). Themes were explored by examining parents' descriptions, and using thematic content analysis, which is a process for encoding qualitative information and applying statistical analysis (Boyatzis, 1998). A coding system was devised so that themes from the interviews, and participant responses, could be systematically coded into quantifiable categories. Relevant behaviours were documented in the coding spreadsheet, and parents were assigned to particular categories for a range of behaviours, according to their responses. This quantifying of qualitative data (Sandelowski, 2000) enabled statistical analysis of qualitative data: this method has been used to great effect in healthcare research (O'Cathain et al., 2010).

The coding system was approved by professor of anthropology and director of the parent-infant sleep lab, Helen Ball, who is familiar with the technique. An independent researcher who is experienced in sleep research with preschool children and their parents (Meg Newark) coded the first two interviews so that the coding system could be verified. Meg and I agreed on 85% of the responses, and reliability achieved a Kappa score of 0.71, indicating that there was substantial agreement beyond chance (McGinn et al., 2004). Discrepancies were discussed, and the coding system was clarified. Once the coding system had been finalised, I listened to the audio recordings of each interview in turn and coded responses into the spreadsheet.

The coding system was devised after conducting and listening to the interviews, once key topics and themes had been identified (so it could be decided what variables to code), and the range of participant responses was known (so the codes for each variable could be devised). This list of codes is not exhaustive since it was not possible to code everything that was discussed in the interviews; rather, the coding system included what I felt to be the most salient themes and participant responses having conducted and listened to all of the interviews.

Table 4.5 shows the topics which were coded, and which are explained and described throughout Chapters 6 and 7. (Some further codes were devised which were not used in further analyses since they were deemed to be less salient, or because data was missing for a large proportion of participants: see Appendix H for these codes and their frequencies). Extracts from the interviews will be used throughout Chapters 6 and 7 to present parents' attitudes and opinions in their own words, and to illustrate the codes which were devised.

Table 4.5: Sleep, Diet and Activity Information Variables which were Derived from Interview Data

Variable		Codes
Interviews: Sleep	Child's usual sleep location	Own bedroom, shared bedroom with siblings (shared or own bed), shared bedroom with parents (shared or own bed), other
	Parent-reported child problems with sleep onset	Parent does or does not think child has problems with sleep onset
	Parent-reported child problems with night wakings	Parent does or does not think child has problems with night wakings
	Reasons why sleep is importance	Reasons reported by parents for the importance of sufficient sleep, and their frequency
	Sleep advice	Did parents receive advice about child sleep, by whom
	Regularity of child's bedtime	Always the same except for rare occasions, usually the same can be later sometimes, no set time
	Reasons why regular bedtimes are important	Reasons reported by parents and their frequency
	Bedtime routine	Components reported by parents and their frequency
	How child wakes in the morning	Wakes self, woken by siblings, woken by parents
	Parent's opinion about child napping	Try to prevent, allow if child prefers, encourage napping, unable to answer because child does not want naps
	Parents' attitude to child sharing their bed	Try to prevent, or allow, and reasons
	Frequency of child sleeping in parents' bed	Regularly (at least weekly) or rarely (less than weekly)
Interviews: Diet and mealtimes	Parental concern about child's diet	No concern, child is fussy but parent not concerned, would like their child to eat more of something, would like their child to eat less of something
	Parental concern about quantity of child's food	No concern, concerned their child eats too little, concerned their child eats too much
	Restriction of food types by parents	No food types restricted, everything allowed in moderation, some foods restricted
	Child choice of meals	No choice, some choice, can choose anything
	Child access to food	Cannot reach food, can reach fruit only, can reach all food
	Frequency of supper consumption	Less than weekly, a few days a week, most days
	Frequency of breakfast consumption	Child eats breakfast every day, child sometimes refuses to eat it, parent does not provide breakfast every day
	Regularity of mealtimes	Parent keeps regular meal times, meal times are regular due to circumstance, no set meal times
	Usual meal location	Kitchen or dining room table, living room table, sofa, floor, standing, kitchen worktop
Interviews: Activities	TV in child's bedroom	Yes or no
	Parental restriction of child's TV viewing	Amount is restricted, would be restricted if child wanted to watch more, TV is not restricted
	Encouragement of child activities	Weekly child-centred activities, or no weekly child-centred activities
	Encouragement of child to be fit & active	Parent did or did not spontaneously discuss this
	Do parents encourage reading or flash cards	Parent did or did not spontaneously discuss this

Analysis Plan

Qualitative interview data were described and analysed throughout the process of data collection and analysis. These qualitative data were able to explain and complement the quantitative data as it was analysed.

To begin the quantitative analyses, some initial analyses were performed (presented in Chapter 5). Actigraphy-derived sleep and wake times and nap durations were compared to diary-derived estimates in order to assess the validity of the diaries. Then, possible variation in children's behaviours associated with days of the week (week and weekend), daylength, and nursery schedule (morning or afternoon) was assessed, in order to evaluate whether further analyses should account for such variation. Correlations were assessed between children's sleep and body composition.

Following these initial analyses, the main quantitative analyses were performed. Data analysis followed this format: for each topic in turn (sleep, food intake and activities), 1) quantitative data from the diaries were analysed, 2) associations of quantitative data from the diaries with ethnicity, SES, and anthropometric data were examined, 3) qualitative information from the interviews was explored, and themes and categories were created, 4) associations between the data from the interviews and the diaries were assessed.

Once this process had been completed for sleep, food intake and activities, then associations were examined between the quantitative diary data for each of these categories. The themes and categories which were developed from the interview data, and demographic variables, were incorporated into analyses as appropriate.

Statistical Analyses

All statistical analyses were performed in SPSS version 15.0. Descriptive analyses were performed, followed by associations amongst variables. For continuous variables, histograms were visualised so that variables could be assigned as normally or non-normally distributed. Correlations between normally distributed continuous variables were analysed using Pearson's r, and correlations including non-normally distributed continuous variables were analysed using Spearman's r_s.

To examine variation in continuous variables between two groups, independent t-tests (for normally distributed continuous variables) and Mann-Whitney U tests (for non-normally distributed continuous variables) were performed. Associations of continuous variables with categorical data were assessed with one-way ANOVA (for normally distributed continuous variables) and Kruskal Wallis tests (for non-normally distributed continuous variables). Associations between categorical variables were assessed with chi-square tests. Chi-square was not performed where 20% or more of cells had expected count less than 5. Where statistical associations are presented in the following chapters, the types of test used for analyses are shown in the tables. For normally distributed continuous data, means and standard deviations are shown in results tables; for non-normally continuous distributed data, medians and ranges are shown in results tables.

Power calculations were not performed, and so the strength of associations and the power to detect differences in the sample cannot be determined; however, associations were considered statistically significant if $p \leq .05$. Where multiple correlations are carried out in the same dataset, as in this study, it is important to be circumspect about significant correlations, which may arise falsely due to the number of correlations performed. However, it was not necessary to statistically control for this in the current exploratory study since it did not aim to test specific hypotheses. The exploratory design also prevented post hoc tests from being necessary. Trends in the data were examined, and hypotheses were generated, to be tested with more rigorous statistical techniques in future studies.

Missing Data

Where themes did not arise and specific topics were not discussed during interviews, then the relevant category was left blank on the coding spreadsheet. Responses were only coded if they were explicitly discussed since the absence of a particular response did not mean that it was not applicable to a participant, just that it was not spontaneously discussed. Participants with some missing data were not excluded from all analyses, but were excluded only from analyses involving the variables for which data was missing. Similarly, parents who did not return the diaries were not excluded from analyses altogether, but were excluded from all analyses involving diary variables. Children who were not measured were excluded from the relevant analyses only.

Where parents returned a partially-completed diary, the days which had been completed fully were entered. For food intake and activity data, daily servings and durations, respectively, were only entered into the spreadsheet if data for the full day was available. Where the sleep section was complete and parents had not documented any naps, then nap duration was assumed to be zero. Where parents documented that children had had a nap, but its duration was not documented, then nap duration and total daily sleep duration were left blank for that day.

Some variables could only be included for participants for which full diary data were available. For example, children were only classified as not consuming any carbonated drinks or as not falling asleep on the sofa on any night if data were available for every day or night. For other sleep and activity variables, week and weekend means were calculated when at least one week and weekend value was available, respectively. Daily means for food intake were calculated when full data for at least one day was available. Calculating means for incomplete diaries in this way did not affect the distribution of variables in the dataset: I compared this dataset to a dataset where only participants with fully complete diary data were included, and minimum and maximum values, means and medians were similar. Correlations within the dataset were also similar (the same variables were significantly correlated together). Therefore participants with some missing data were included in analyses where possible. Results tables include the number of participants (n) being included in analyses.

Summary: Data Analysis

Interview data were analysed qualitatively throughout. For quantitative analyses, interviewee responses were coded into categories. Basic calculations were performed on diary, actigraphy and anthropometric data to produce mean values for sleep variables, activity durations and body composition measures. Foods were grouped into categories. Descriptive analyses and associations amongst variables were calculated in SPSS.

Chapter 4 Summary: Methods

This chapter described the research design and methodology. This was an exploratory study to investigate the topic without any explicit expectations, and to generate hypotheses for future research. Participants were 3-year-old children and their parents, recruited non-randomly from government-funded nursery schools in both deprived and affluent areas in Stockton-on-Tees.

Considering their appropriateness, feasibility and acceptability, different methods were selected to explore different aspects of the research question. A mixed methods design was used to enable enhanced understanding of the topic. Qualitative methods (semi-structured interviews) investigated parents' attitudes and practices regarding their children's sleep, food intake and activities, and general approaches to parenting. Quantitative methods (diaries and anthropometric measurements) assessed children's sleep, food intake, physical activity and TV viewing over a typical 4 day/5 night period, and children's body composition. A subgroup of children participated in actigraphy in order to validate the sleep section of the diaries.

The next chapter will describe the final sample, including the number of participating nurseries and families, and demographic characteristics of the children and their parents. It will also present some initial analyses.

Chapter 5: Participant Characteristics and Initial Analyses

This chapter will describe the final sample, present some initial analyses in preparation for the main data analyses, and examine associations of sleep with body composition. Regarding participant characteristics, the chapter will a) report the participation rate of nurseries and families, b) describe participant demographics, and c) describe children's body composition and prevalence of overweight and obesity. Regarding initial analyses, this chapter will inform further analyses by d) assessing the accuracy of parental reporting by comparison with actigraphy (to assess whether further analyses can consider parental diary reports to be reliable), and e) considering variability in children's typical sleep, food intake and activity, including weekly and seasonal variation (in order to incorporate any systematic variation such as weekly or seasonal variation in children's behaviours into further analyses). Finally, this chapter will f) examine correlations of children's sleep with body composition, addressing secondary aims one and two.

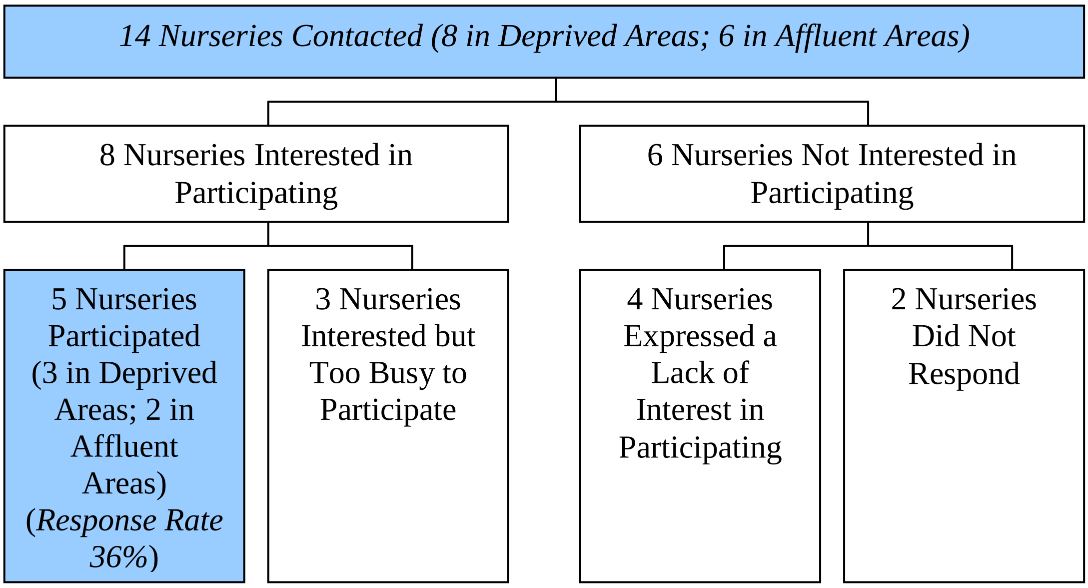
Participants and Participation Rate

This section of the chapter will report the number of nursery schools which were contacted and which participated; and the number of parents and children who were approached and who participated in each stage of the study.

Nursery School Participation Rate

Within the two selected areas in Stockton-on-Tees (deprived and affluent), 14 state-funded primary schools with affiliated nursery schools were identified. The head-teachers of these schools were contacted by letter. Some head-teachers or nursery teachers responded directly to the letter, and others were contacted by phone following the letter. The responses of the contacted nursery schools are shown in Figure 5.1.

Figure 5.1: Response Rate for the Nursery Schools Contacted



Five nursery schools agreed to participate, with similar response rates in deprived (38%) and affluent (33%) areas.

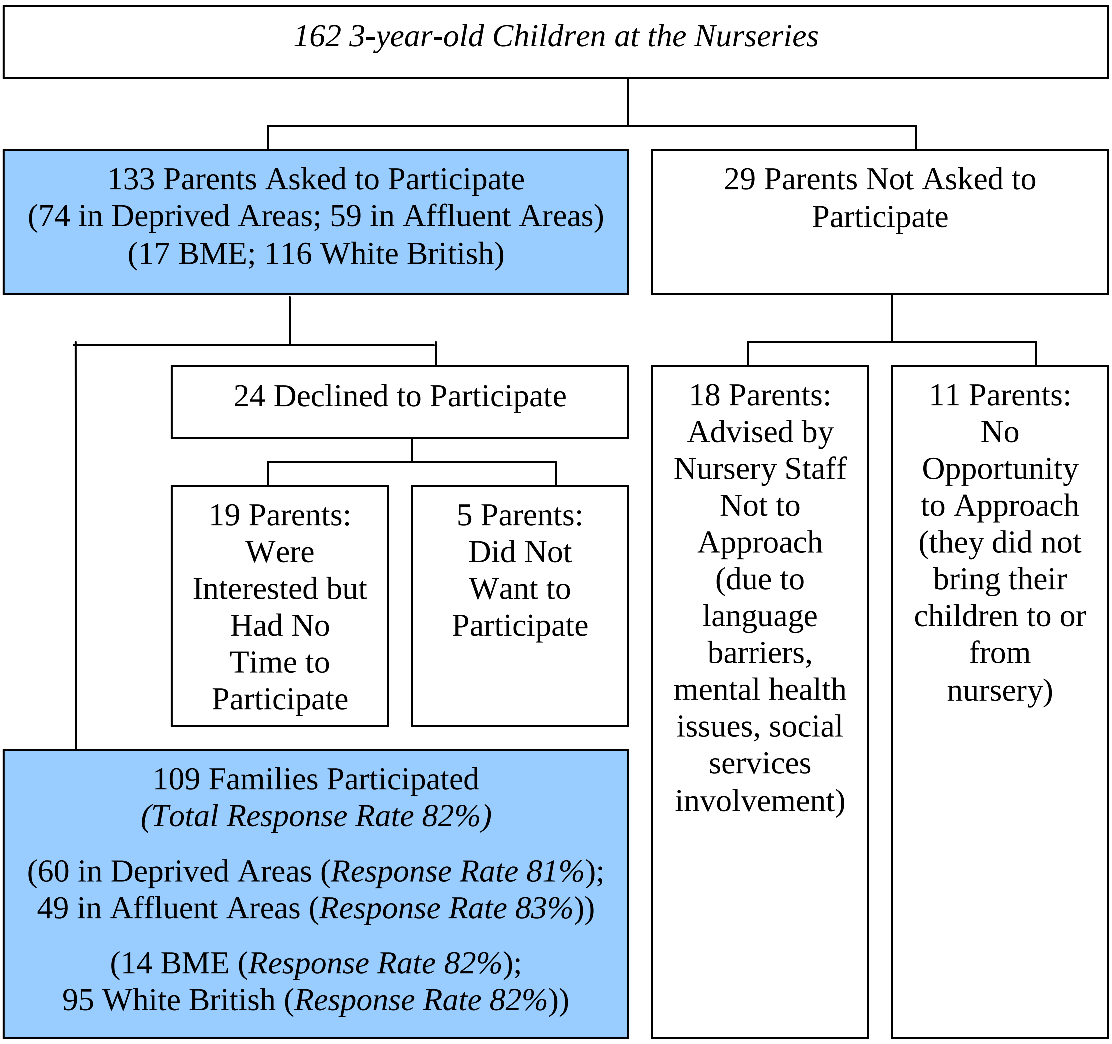
Family Participation Rate

Across the 5 nursery schools which participated, there were a total of 162 3-year-old children registered. Parents of 133 children were asked to participate, and a total of 109 consented to participate. The responses of the parents are shown in Figure 5.2.

Of the parents asked to participate, more than 80% consented. Response rates were similar across deprived and affluent areas, and between parents of BME and white British children who were eligible to participate. However, more BME than white British families were ineligible, due to inability to conduct an interview in English, and so the number of BME families who were asked to participate was disproportionately small.

Although the study aimed to recruit 80 families, this number was reached ahead of the predicted end date for data collection. Rather than ending data collection once 80 families had participated, all eligible families were asked to participate in each nursery and data collection ended once all of the consenting parents in each nursery had participated.

Figure 5.2: Response Rate for Parents at the Nursery Schools



Participation Rate for Each Research Method

All 109 parents who consented to participate were interviewed. The majority of interviews were with children's mothers only (see Table 5.1). Where multiple caregivers attended an interview, the responses of the interviewees were compatible, and so analyses of interview data were not hampered by having multiple respondents.

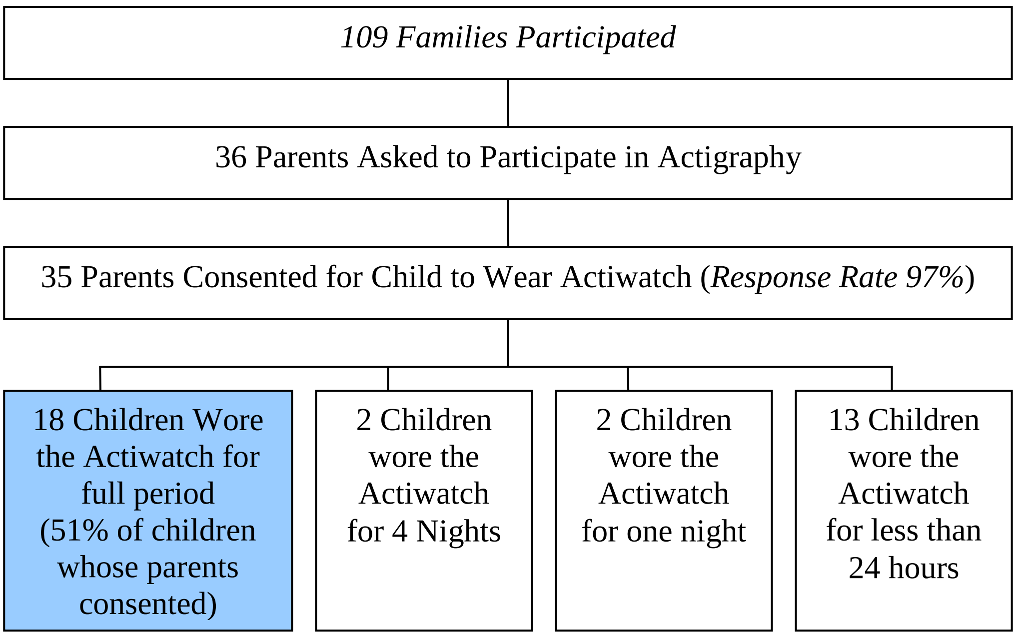
Table 5.1: Caregivers who were Interviewed

Interviewees	Number (%)
Mother only	95 (87)
Father only	6 (6)
Both mother and father	4 (4)
Mother and grandmother	2 (1)
Mother and stepfather	1 (1)
Legal guardian (grandmother)	1 (1)

The majority of parents who were interviewed returned their diaries (n=91); however, some parents did not return them, or returned them blank. Where large sections were incomplete or missing then I asked parents to fill in the diary for another day where possible, although some parents said that they did not have time. All 109 parents consented for their children to be measured; some children did not tolerate being measured, but the majority (n=102) did.

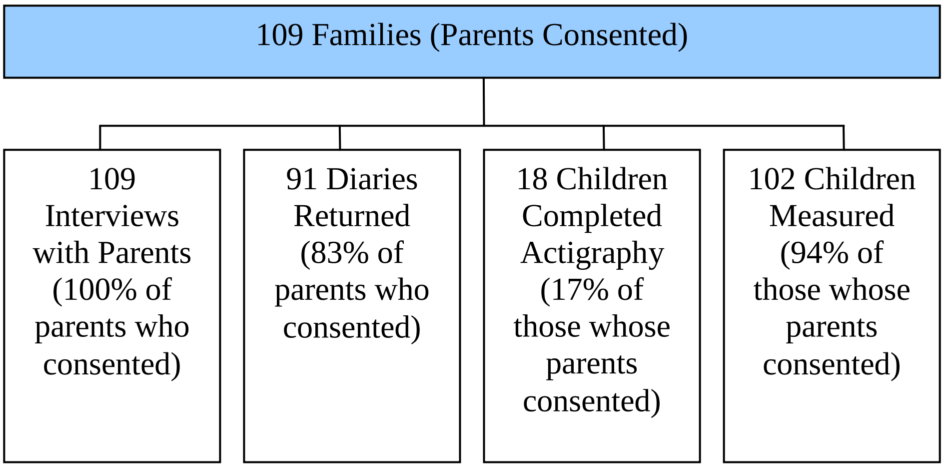
Of the 109 parents who consented to participate, a sub-group were asked for their children to participate in the actigraphy phase of the study. All but 1 of the parents who were asked consented for their child to participate; however, half of the children of consenting parents did not tolerate the actiwatch for the full time period (Figure 5.3). A total of 18 children wore the actiwatch for the full 4 day/5 night period.

Figure 5.3: Response Rate for the Actigraphy Phase of the Study



A summary of the number of parents and children who participated in each stage of the study is shown in Figure 5.4.

Figure 5.4: Number of Participants in Each Stage of the Study



Summary: Participants and Participation Rate

Five nursery schools participated in the study. Of the eligible families at the nurseries, more than 80% consented to participate and were interviewed. Response rates were similar in the deprived and affluent areas, and between white British and BME families, although a greater proportion of BME families were ineligible to participate. The majority of participating parents returned the diary, and almost all of the children were measured. A subgroup of 18 children wore an actiwatch for the full 4 day/5 night period.

Socioeconomic and Demographic Characteristics

This section of the chapter will describe the sample's socioeconomic and demographic characteristics. Characteristics of the children and their parents will be outlined, and the deprived and affluent areas (and families in each area) will be described and compared.

Characteristics of the Children

Demographic characteristics of the children are shown in Table 5.2. Children were spread evenly across quarterly age groups and across genders. Half of the children were first born, and the number of siblings ranged from 0-5. Few children were reported to have had low birth weight (4%). A fifth of parents did not comment on whether they breastfed their children, and the majority of parents did not breastfeed for one month or more. Due to the low frequency of low birthweight children and of breastfeeding for at least one month, birthweight and breastfeeding variables were not considered in further analyses.

Table 5.2: Demographic Characteristics of the Children

Characteristics of the Children		n (%) or mean ± SD
Age		3.44 ± .29 years
Age group	3 years 0-3 months	27 (25)
	3 years 4-6 months	31 (28)
	3 years 7-9 months	27 (25)
	3 years 10-12 months	24 (22)
Gender	Male	57 (52)
	Female	52 (48)
Ethnicity	BME	14 (13)
	White British	95 (87)
Number of Siblings	0	29 (27)
	1	48 (44)
	2	22 (20)
	3	7 (6)
	4	0 (0)
	5	3 (3)
Birth Order	1	53 (49)
	2	35 (32)
	3	15 (14)
	4	4 (4)
	5	1 (1)
	6	1 (1)
Birthweight	Normal	85 (78)
	Low (below 5lb8oz)	4 (4)
	Unknown	20 (18)
Breastfed	Not at all	48 (44)
	Less than one month	11 (10)
	One month or more	27 (25)
	Unknown	23 (21)

Eighty seven percent of children in the study were white British. Other ethnicities represented were predominantly South Asian, but also included Black African and Caribbean: due to the low frequencies of ethnicities other than white British, these were combined into a British minority ethnic (BME) category. Although a higher proportion of BME compared to white British families were ineligible to participate due to language barriers (see above), the proportion of non-white, BME families included in this study (13%) was greater than that in the borough of Stockton-on-Tees (2.3%), meaning that BME families were not disproportionately under-represented in this study (Stockton Borough Council).

Regarding health status, two children suffered from chronic eczema, one girl was being treated for an ear infection, another was receiving antibiotics for chest problems, and one boy was being treated for cancer at the time of the study. All of the other children were in good health. Since the number of children suffering from an illness was small (5%), this was not accounted for in further analyses.

Characteristics of the Parents

Socioeconomic and demographic characteristics of the parents are shown in Table 5.3.

Table 5.3: Socioeconomic and Demographic Characteristics of the Parents

Characteristics of the Parents		n (%) or mean ± SD
Mother's age at child's birth (years)		27.51 ± 6.09 (range 14-41)
Mother's Employment status	Not employed	63 (58)
	Employed	46 (42)
Father's Employment status	Not employed	12 (11)
	Employed	82 (75)
	Unknown (Father not Present)	15 (14)

Mother’s age at the birth of their 3-year-old child ranged from 14-41 years. The majority of mothers were unemployed, whilst the majority of fathers were employed.

Characteristics of the Household

Household composition and the number of people per room in the house are shown in Table 5.4. All but one child lived with their biological mother, and the majority of children lived with both of their biological parents. The number of people per bedroom in the household (which indicates household crowding) ranged from 0.6 to 2.7.

Table 5.4: Characteristics of the Household

Household Characteristics		n (%) or mean ± SD
Household Composition	Both parents	86 (79)
	Both parents & grandparent(s)	2 (2)
	Mother only	13 (12)
	Mother & grandparent(s)	4 (4)
	Mother & her partner	2 (2)
	Mother, her partner & grandparent(s)	1 (1)
	Grandmother only	1 (1)
Household Crowding	Number of people per bedroom in the house	1.29 ± .43 (range .60-2.67)

Characteristics of the Deprived and Affluent Areas

Around half of the participants (55%) were recruited from the three nurseries in deprived areas, and half from the two nurseries in affluent areas. Each nursery was located in a separate ward in Stockton-on-Tees; based on the Index of Multiple Deprivation, the three nurseries in the deprived areas were in the top 20% most deprived wards in England, and the two nurseries in the affluent areas were in the top 10% most affluent wards in England (see Table 5.5).

Table 5.5: Level of Deprivation of each Nursery

Nursery		Number of Participants	Index of Multiple Deprivation (2007)
Deprived	1	35	1,533
	2	15	25
	3	10	497
Affluent	4	25	7,231
	5	24	7,445
National			of 7,936

The Index of Multiple Deprivation was undertaken by the Office of the Deputy Prime Minister in 2007. It measures deprivation based on income; health and disability; crime; employment; education, skills and training; living environment; and barriers to housing and services. There are 7,936 wards nationally; a low score represents an area of high deprivation (see Stockton Borough Council).

All of the families that participated lived in the catchment area for the nursery from which they were recruited; hence they are likely to be representative of families in the ward in which their nursery was located. Characteristics of the deprived and affluent wards are shown in Table 5.6.

Table 5.6: Characteristics of Deprived and Affluent Areas

Nursery Area: Ward of Stockton-on-Tees		Adults with No Qualifi-cations (%) (2001 census)	Adults with Low Literacy (%) (2003)	Adults with Low Numeracy (%) (2003)	Weekly House-holds Earnings (£) (2001-2002)	Employ-ment Rate (2008)	Recipients of Income Benefits (%) (2006)	Single Parent House-holds (%) (2001 census)
Deprived	1	48.9	18.3	61.1	370	71.5	19.7	6.2
	2	57.9	29.3	71.4	270	51.4	42.6	10.9
	3	49.2	21.1	67.0	340	60.3	25.4	12.2
Affluent	4	16.1	5.0	38.0	750	88.5	3.4	4.4
	5	24.2	5.0	38.0	750	84.1	5.4	4
National		28.9	11.0	47.0	550	74.9	13.3	6.4

The proportions of adults with low literacy and numeracy skills were calculated by the Department for Education and Skills; average household earnings were estimated by Stockton Borough Council; the proportion of recipients of income benefits was reported by the Department for Work and Pensions; adults with no qualifications and single parent households were taken from the 2001 census; employment rate was taken from the Annual Population Survey of 2008. All data are available at Stockton Borough Council.

In the deprived study areas, the proportion of adults with no qualifications, with low literacy and numeracy, and in receipt of income benefits was above the national average, whilst employment and the average weekly household earnings were below the national average. The proportion of single parent households was similar to or above the national average in each of the deprived wards.

In the affluent study areas, the proportion of adults with no qualifications, with low literacy and numeracy, and in receipt of income benefits were below the national average, whilst employment and the average weekly household earnings were above the national average. The proportion of single parent families was below the national average.

Whilst the above data document general variation between the deprived and affluent areas, characteristics of families in deprived and affluent areas in this sample in particular, and comparisons between them, are shown in Table 5.7.

Table 5.7: Characteristics of Families Recruited from Deprived and Affluent Areas

Independent t-test, chi-square, One-way ANOVA, Mann Whitney U	Deprived (n=60)	Affluent (n=49)	Statistic	p value
BME (%)	20	4	X^2=.6.11	.019
Number of Siblings (median (range))	1.0 (0-5)	1.0 (0-5)	U=1405	.677
Birth Order (median (range))	2.0 (1-5)	1.0 (1-6)	U=1361	.471
Number of People per Bedroom (mean (SD))	1.47 (.45)	1.09 (.32)	t=4.71	<.001
Maternal Employment (%)	36	51	X^2=2.61	.121
Paternal Employment (%)	76	98	X^2=10.57	.001
Single Parent Households (%)	28	2	X^2=13.53	<.001
Mothers' Age at Child's Birth (Years) (mean (SD))	24.6 (5.6)	31.0 (4.7)	F=38.51	<.001

Consistent with the descriptions of the areas above, families in the deprived areas had more crowded houses (more people per bedroom) and more paternal unemployment compared to those in affluent areas. Single parent households were more common in deprived areas, but there was no variation in number of siblings of child's birth order. Mothers in deprived areas were younger at the birth of the focus child compared to those in affluent areas.

The proportion of BME children recruited was higher in deprived compared to affluent areas. This is consistent with the distribution of BME residents in Stockton-on-Tees (see Table 5.8), with deprived wards generally having a higher proportion of non-white residents compared to affluent wards.

Table 5.8: Proportion of Non-White Residents in Each of the Study Areas

Nursery Area: Ward of Stockton-on-Tees		Non-White (%) (2001)
Deprived	1	2.8
	2	11.5
	3	6.7
Affluent	4	2.6
	5	4.5

Proportion of non-white residents according to the 2001 census

Summary: Socioeconomic and Demographic Characteristics

Children's birthweight, breastfeeding and illness were not considered in further analyses due to low frequencies. The proportion of BME participants was greater than the

Stockton-on-Tees average, and was greater in the deprived compared to affluent group. Characteristics of the deprived areas compared to affluent areas were lower qualifications and household income, and greater unemployment. In this sample, the deprived group had more crowded houses, more paternal unemployment, more single parent households, and younger mean maternal age.

Children's Body Composition and Obesity Prevalence

This section of the chapter will describe the body composition of the children, and the prevalence of overweight and obesity. Variation in body composition with SES and ethnicity will also be examined.

Children's Body Composition

Descriptive data for children's anthropometric measurements are shown in Table 5.9.

Table 5.9: Anthropometrics: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Height (cm)	102	88.07	112.67	99.40	4.63	99.43
Weight (kg)	102	11.80	23.60	16.29	2.10	16.00
BMI	102	13.23	20.86	16.44	1.25	16.34
Waist Circumference (cm)	101	43.07	60.57	52.08	2.91	52.10
Triceps Skinfold (mm)	99	5.50	15.83	10.93	2.31	11.23
Subscapular Skinfold (mm)	97	4.27	15.87	6.42	1.75	6.03

SD scores were calculated for BMI and waist circumference using British 1990 reference data (Cole et al., 1990), and for triceps and subscapular skinfold thicknesses using WHO 2006 reference data (WHO, 2006). Descriptive data for these SD scores are shown in Table 5.10.

Table 5.10: Anthropometric SD Scores: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
BMI SD Score	101	-2.32	3.00	.37	.91	.33
Waist Circumference SD Score	100	-2.45	2.73	.57	.86	.71
Triceps Skinfold SD Score	98	-1.59	2.87	1.16	.94	1.32
Subscapular Skinfold SD Score	96	-1.87	3.12	.21	1.08	.13

Associations amongst anthropometric SD scores are shown in Table 5.11. The measures of body composition were all strongly positively correlated.

Table 5.11: Associations of Anthropometric SD Scores

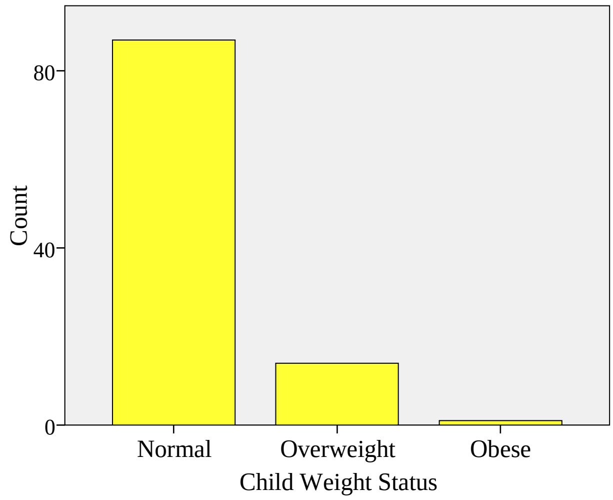
Pearson's Correlations, r	Subscapular Skinfold SD Score (n=96)	Triceps Skinfold SD Score (n=98)	Waist Circumference SD Score (n=100)
BMI SD Score (n=101)	.62 ***	.55 ***	.79 ***
Waist Circumference SD Score (n=100)	.56 ***	.36 ***	
Triceps Skinfold SD Score (n=98)	.63 ***		

* p≤ .05 ** p≤ .01 *** p≤ .001

Prevalence of Overweight and Obesity

Based on the cut off values calculated by Cole et al. (2000), children were categorised as being ideal weight, overweight or obese (see Graph 5.1).

Graph 5.1: Weight Status of the Children



Mean BMI and frequency of overweight and obesity by gender for children in this sample and for 3-year-old children in the Health Survey for England (2008) are shown in Table 5.12. Notably, prevalence of obesity in this sample was lower than the national reference data; prevalence of overweight was also slightly lower. (I did not observe a higher prevalence of overweight/ obesity amongst the children who did not participate;

and the high response rate for this study suggests that a large number of overweight or obese children were not non-respondents.)

Table 5.12: Mean BMI and Frequency of Overweight and Obesity in Boys and Girls Compared to Reference Data

	Mean BMI		Overweight (%)		Obese (%)	
	Boys	Girls	Boys	Girls	Boys	Girls
This Sample of Children (boys n=57; girls n=52)	16.8 ± 1.20	16.1 ± 1.23	14	14	2	0
Health Survey for England (2008) *Aged 3 Years*	16.6 ± 0.12	16.8 ± 0.21	16	16	8	11

Body Composition and SES and Ethnicity

Previous research has found that obesity is more prevalent in lower socioeconomic groups, and in ethnic minorities (see Chapter 3), and so body composition was compared between deprived and affluent groups, and between BME and white British children.

There was no significant variation in body composition SD scores between children living in deprived versus affluent areas in this sample (results not shown, all p>.05). This is contrary to national survey data from England (see Chapter 3).

Body composition SD scores were lower in BME compared to white British children (see Table 5.13). This is the opposite trend to that identified in national surveys of British children, which demonstrate ethnic minority groups to be at a greater risk for obesity compared to white British children (see Chapter 3). The different trend may be due to the small proportion of BME compared to white British children in this sample.

Table 5.13: Comparisons of Anthropometric SD Scores with Ethnicity

One-Way ANOVA	White British (n=95)	BME (n=14)	F value	p value
BMI SD Score (mean (SD))	.45 (.87)	-.17 (.95)	6.02	.016
WC SD Score (mean (SD))	.66 (.84)	.06 (.87)	6.03	.016
Triceps Sf SD Score (mean (SD))	1.24 (.92)	.65 (.95)	4.59	.035
Subscapular Sf SD Score (mean (SD))	.25 (1.10)	-.03 (.89)	.90	.408

Summary: Children's Body Composition and Obesity Prevalence

The proportion of overweight and obese children was lower in this sample compared to the nation average. Contrary to national findings, body composition did not vary between children living in deprived versus affluent areas, and BME children had lower body composition SD scores compared to white British children.

Validation of Parental Diaries (Sleep Section) with Actigraphy

This section of the chapter will examine the validity and accuracy of parental report of children's sleep, by comparison with actigraphy, in order to assess the reliability of parentally-reported data. Specifically, agreement will be assessed between actigraphy-derived and diary-derived measures of children's sleep and wake times and nap durations for the subgroup of children who participated in the actigraphy phase of the study.

Diary- and Actigraphy-Derived Measures of Children's Sleep

Total daily sleep duration was calculated by combining parental diary reports of nighttime sleep duration, calculated using sleep onset and wake up times, with daytime nap duration. Therefore key sleep variables in this study were sleep onset time, wake up time and daytime nap duration: as such, these variables were compared across methods. Actigraphy and diary measures for each of these variables have been compared in previous studies (Wiggs et al., 2005; Lockley et al., 1999).

Nighttime sleep duration was not compared directly between methods, because diary estimates of nighttime sleep duration were calculated from sleep start and wake up times, which were compared themselves with actigraphy. Sleep quality variables (including number and duration of night wakings, and sleep efficiency) were not compared between methods because sleep quality was not a main focus of this study (see Chapter 2).

There were 18 children included in analyses, for which full actigraphy and diary data were available for 5 nights and 4 days. Comparisons between diary and actigraphy values were made using methods appropriate for assessing agreement between two methods of measurement (Bland & Altman, 1986).

Comparisons of Sleep Onset and Wake Up Times

For sleep onset and wake up times, comparisons between methods were drawn for a single night (the middle night), and also for the mean of the 5 nights (see Table 5.14): nightly data for actigraphy and diary measures has been averaged over nights for individual children in this way in other studies (Acebo et al., 2005).

Table 5.14: Comparisons of Diary- and Actigraphy-Derived Sleep Onset and Wake Times

Sleep Variable (all n=18)		Method: Diary	Method: Actigraphy	Paired Samples t-test, t	Pearson's Correlation, r	Linear Regression, R^2
Sleep Onset Time (hh:mm)	Mean Across the 5 Nights	20:15 ± 60 mins	20:23 ± 63 mins	-1.52	.98 ***	.96 ***
	Third Night	20:30 ± 74 mins	20:37 ± 78 mins	-1.87	.98 ***	.95 ***
Wake Time (hh:mm)	Mean Across the 5 Nights	07:31 ± 37 mins	07:33 ± 38 mins	-1.36	.99 ***	.98 ***
	Third Night	07:34 ± 57 mins	07:37 ± 54 mins	-0.86	.97 ***	.95 ***

* p≤ .05   ** p≤ .01   *** p≤ .001

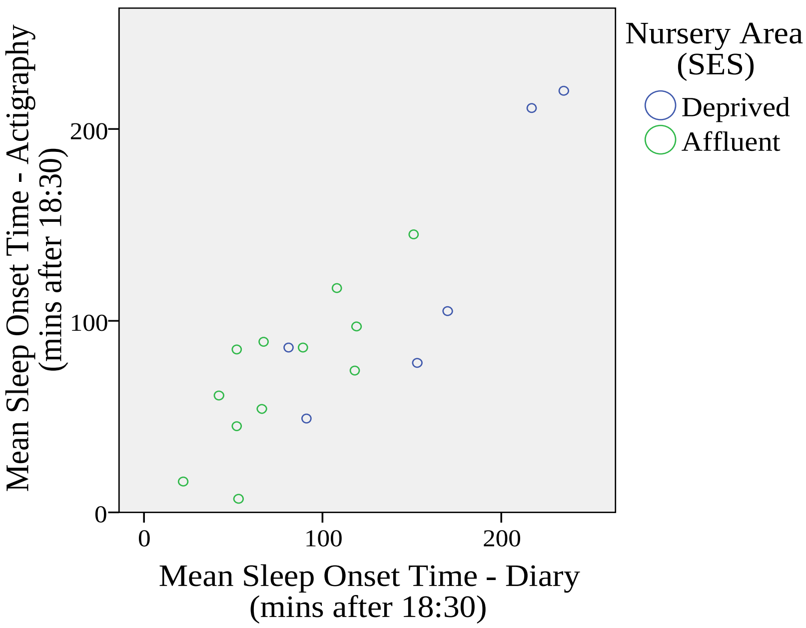
For each sleep variable, actigraphy values were later than diary estimates. The mean difference was no more than 8 minutes for each measure. A difference of 15 minutes between objective and subjective measures of sleep onset in a previous study was suggested to be clinically insignificant (Wiggs et al., 2005), and differences of over 20 minutes for sleep start and sleep end times in children was considered to be satisfactory agreement in another study (Werner et al., 2008). The difference here of 8 minutes is smaller than those studies, so is also likely to have an insignificant impact on the interpretation of results.

The lack of significant t values confirms that any difference between diary and actigraphy values is non-significant. The high values of Pearson’s r indicate strong correlations between the diary and actigraphy measures, whilst the high values of R^2 indicate that the diary estimates can predict 95% or more of the variation in the actigraphy sleep and wake times. Therefore, there is good correlation between the two methods. Bland-Altman plots showed no systematic form of bias; this further suggests that the two methods (diary report and actigraphy) can be used interchangeably (see Appendix I: Bland-Altman Plots Comparing Diary and Actigraphy Measures of Sleep and Wake Times).

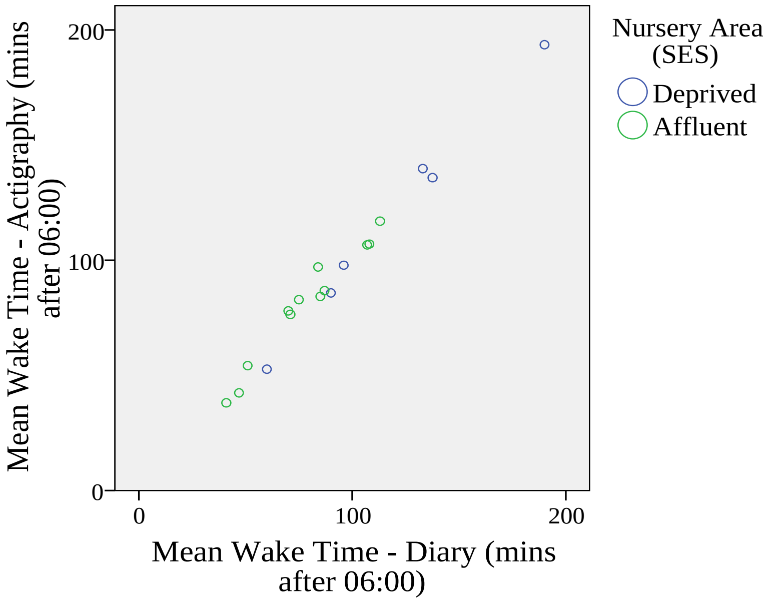
Correlations between diary- and actigraphy-derived mean sleep onset times and mean wake times were identified separately for children from deprived (n=6) and affluent areas (n=12) (see Graphs 5.2 and 5.3). (More children from affluent than deprived areas participated in the actigraphy phase of the study, because more actiwatches were available for use during the period that families were recruited from affluent nurseries.)

There were no systematic differences in the relationship between diary and actigraphy measures of children's sleep and wake times for families from deprived versus affluent areas, which indicates that parents from both areas were equally accurate at reporting sleep onset and wake times in the diaries. Werner et al. (2008) also reported that SES does not influence the difference between diary and actigraphy measures of children's sleep.

Graph 5.2: Correlations between Diary- and Actigraphy-Derived Sleep Onset Times in Different SES Groups



Graph 5.3: Correlations between Diary- and Actigraphy-Derived Wake Times in Different SES Groups



Comparisons of Daytime Nap Duration

For daytime nap duration, comparisons between methods were made for mean daily nap duration over the 4 daytime periods (see Table 5.15).

Table 5.15: Comparisons of Diary- and Actigraphy-Derived Daytime Nap Duration

Sleep Variable (n=18)		Method		Paired Samples t-test, t	Pearson's Correlation, r	Linear Regression, R^2
		Diary	Actigraphy			
Nap Duration (mins)	Mean Across 4 Days	12 ± 25	17 ± 14	-1.1	.81 ***	.66 ***

* p≤ .05 ** p≤ .01 *** p≤ .001

Again, high values of Pearson's r and R^2 indicate strong correlation between the diary and actigraphy values, whilst the lack of significant t value suggests that there is no significant difference between diary and actigraphy reports. The discrepancy between diary- and actigraphy-derived mean daytime nap duration is 5 minutes, which is smaller than the discrepancy in sleep start and wake up times. Therefore, there is good correlation between the two methods for daytime nap duration in addition to sleep onset and wake up times.

Validity of Parental Reports of Children's Sleep Duration

Sleep onset time, wake up time and daily nap duration measured by parental diary report were significantly correlated with actigraphy-derived values; there was no significant difference between the times reported by each method, and they predicted each other significantly well. The mean discrepancies between the times reported by each method were no more than 8 minutes. Since actigraphy has been favourably validated against polysomnography for the recording of children's sleep-wake patterns, including for young children (see Chapter 4), the agreement between the actigraphy-derived and diary-derived children's sleep variables suggests that parents accurately reported their children's sleep-wake patterns in the diaries. Hence the diaries are validated against actigraphy for the assessment of children's nighttime sleep onset and wake up times, and daily nap duration. These variables were used to calculate children's total daily sleep duration, and so diary-derived estimates of children's sleep duration are considered reliable.

Previous studies have similarly found that parents are able to accurately report their preschool children's sleep schedules in daily logs, compared to actigraphy (Tikotzky & Sadeh, 2001), and that diaries and actigraphy may be used interchangeably for the assessment of children's sleep start and end times (Werner et al., 2008). Using a similar method to the present study, Sekine et al. (2002a) compared parental report with actigraphy for sleeping hours in 21 children aged 3 and 4 years, using averages over 3 nights in assumed sleeping hours (calculated as the difference between sleep onset time and wake up time). The difference between parent-reported and actigraphy-derived sleeping hours was 0.79 hours, and Pearson's correlation coefficient was 0.90; the authors concluded that correlation between methods was high, and parent-report could be used to make comparisons in sleep amongst a population. Since the correlation between measures was even stronger in the present study, this confirms that the parental diary estimates are appropriate and valid for this study.

No similar validation was carried out to assess the accuracy of parental documentation of children's food intake and activities in the diaries. However, parental report of food intake and activities has been shown to be accurate in previous studies (see Chapter 4), and since parents in this sample were able to accurately document their children's sleep-wake patterns in the diaries, it is hoped that they also accurately documented their food intake and activities.

Summary: Validation of Parental Diaries (Sleep Section) with Actigraphy

The diaries are validated against actigraphy for the report of children's nighttime sleep onset and wake up times, and daily nap duration. Diary-derived estimates of children's daily sleep duration are therefore validated for use in this study. Parents from deprived and affluent areas were equally accurate reporters of their children's sleep patterns.

Variability in Children's Behaviours

As described in Chapter 2, many previous studies into the sleep-obesity link have used single estimates of sleep duration, or estimates of "typical" sleep patterns, which mask night-to-night variability. The current study was designed to improve on previous studies by examining variability in children's sleep (and also diet and activity). This section of the chapter will examine variability in children's behaviours in relation to days of the week, periods of the year, and timing of nursery schedules. This will assess the need to account for these factors when examining typical behaviours in further analyses. Scenarios in which typical behaviours may not be maintained will be discussed.

Variation in Children's Behaviours through the Week

The lack of nursery schedules (and often parental employment schedules) on weekends means that variation in children's behaviours is possible between week and weekend days and nights. Indeed, children as young as 3-years-old have been found to have different sleep patterns on week and weekend days (Snell et al., 2007), and studies into children's TV viewing commonly examine week and weekend viewing habits separately (Bryant et al., 2007).

In order to examine week and weekend variability in sleep, weeknight (Sunday-Thursday inclusive) and weekend night (Friday-Saturday) means for sleep-wake variables were compared (see Table 5.16).

Table 5.16: Comparisons of Week and Weekend Night Sleep-Wake Patterns

Paired-Samples T-Test	Week Night Mean (sample mean (SD))	Weekend Night Mean (sample mean (SD))	t value	p value
Bedtime (hh:mm) (n=74)	19:43 (0:53)	20:03 (1:02)	-4.29	<.001
Sleep Start Time (hh:mm) (n=85)	20:06 (0:53)	20:26 (0:57)	-4.86	<.001
Wake Time (hh:mm) (n=85)	7:21 (0:39)	7:35 (0:50)	-3.35	.001
Get Up Time (hh:mm) (n=85)	7:28 (0:42)	7:46 (0:53)	-4.15	<.001
Nighttime Sleep Duration (mins) (n=85)	674 (42)	669 (48)	1.11	.269
Daytime Nap Duration (mins) (n=84)	12 (25)	14 (22)	-.44	.663

Bedtime, sleep start time, wake time and get up time were significantly later on weekend compared to week nights. There was no significant difference in nighttime sleep duration, indicating that later sleep start times on weekend nights were compensated for by later wake times. Children napped on average for 2 minutes longer on weekend compared to week days, but this difference did not reach significance.

Comparisons were made between time spent in physical activities and watching TV on week and weekend days (see Table 5.17). Time spent in all physical activity categories, and spent watching TV, was longer on weekend compared to week days.

Table 5.17: Comparisons of Week and Weekend Day Activity Durations

Wilcoxon Signed Ranks Test	Week Day Mean (sample median (range))	Weekend Day Mean (sample median (range))	Z value	p value
Physical Play (mins) (n=81)	108 (0-303)	140 (10-420)	-3.45	.001
Walking (mins) (n=81)	23 (0-175)	35 (0-170)	-2.32	.020
Physical Activities (mins) (n=81)	0 (0-83)	0 (0-300)	-3.17	.002
Total Physical Activity (mins) (n=81)	156 (0-355)	225 (25-550)	-5.14	<.000
TV Viewing Duration (mins) (n=81)	71 (0-300)	105 (0-380)	-3.34	.001

Since sleep-wake patterns and time spent in activities varied between week and weekend nights and days, weighted means were calculated using the equation:

weighted mean = ((week night/day mean x 5) + (weekend night/day mean x 2)) / 7

(Weighted means were calculated for all sleep variables, in order to maintain consistency. Although nighttime sleep duration did not vary significantly between week and weekend days, sleep start time and wake up time did, which were the variables used to calculate nighttime sleep duration. It was therefore appropriate to calculate weighted means for sleep duration in addition to bedtime, sleep start time, wake time and get up time.) As discussed in Chapter 4, food intake variables did not distinguish between week and weekend days, and so non-weighted means were calculated across all days.

Seasonal Variation in Children's Behaviours

There is documented variation in children's sleep duration across seasons (see Chapter 2). This may be due to the effect of daylength: for example, Davis et al. (2004) described how circadian rhythms are affected by light, such as sunlight in the evening, which can affect sleep onset.

As described in Chapter 4, data collection took place throughout a calendar year, with children from deprived and affluent areas participating during both summer and winter, so that there would be no systematic bias. No interviews or diaries were completed for the week following the change either to or from British Summer Time, so that data was not affected accordingly.

For each participant, precise sunrise and sunset times in Stockton-on-Tees on the day of the interview were documented (obtained from Royal Observatory Edinburgh), and daylength was calculated. There were no significant associations of daylength with bedtime, sleep start time, wake time, get up time, nighttime sleep duration, daily nap duration or total daily sleep duration (results not shown, all $p>.05$). This is consistent with the commonly reported use of black-out blinds by parents in this study, to ensure that sleep schedules were adhered to. There were also no significant associations of daylength with daily durations of activities and TV viewing, nor with daily food intake (results not shown, all $p>.05$). Since children's sleep, food intake and activities did not vary according to daylength, seasonal variation will not be considered in analyses.

Variation in Children's Behaviours with Nursery Schedules

Around half of the children (54%) attended morning nursery, and half attended afternoon nursery sessions. In adolescents, school start times influence sleep patterns so that early school start times are associated with shorter sleep duration (Carskadon et al., 1998). A similar affect of school or nursery start times on preschool children's sleep is not documented; in order to assess any variation related to nursery schedules and start times in the preschool children in this sample, comparisons were made between children attending morning and afternoon sessions.

There were no differences in sleep-wake variables, durations of activities and TV viewing, or food intake between children attending morning compared to afternoon nursery sessions (results not shown, all $p>.05$). Perhaps this is because younger children are not affected by nursery start times in the same way as adolescents. Alternatively, it may be because children attending afternoon nursery sessions had to adhere to the earlier school start times of their older siblings, or work schedules of their parents, overriding any influence of their own nursery start times. Since children's sleep, food intake and activities did not vary with timing of nursery session (morning versus afternoon), timing of nursery session will not be considered in analyses.

Variation from Typical Behaviours and Schedules

In addition to the possible causes of systematic variation in children's behaviours discussed above, other factors may cause children's behaviours and schedules to vary from those which occur on typical days. These include special occasions, and time spent with different caregivers.

a) Variation with Special Occasions

Parents were asked to describe typical practices and children's typical behaviours during interviews. They then completed the diary for typical days and nights. Where children were on holiday, were ill, were celebrating special occasions, or schedules were disrupted for other reasons, then the diary was delayed until a period of consecutive typical days and nights was resumed. Therefore parents' interviews and diary data reported typical or usual behaviours and schedules for their children only.

Variation in children's behaviours with special events was not documented. The frequency and degree of this variation, and any impact on the research findings, cannot be determined.

b) Variation with Caregivers and between Households

All of the children in this study attended the nursery from which they were recruited for 5 days each week (either morning or afternoon sessions). Activities during nursery sessions were similar for all children: no children were provided an opportunity to nap; all children were offered milk and one piece of fruit each day; and all children undertook a similar amount of active play. A further 11 children attended a private nursery at least once a week, in addition to spending each day at the focus nursery. Parents were asked to complete the diary for these periods by asking nursery staff for the relevant information, so that any variation should be documented in the diaries.

Some children were regularly cared for by people other than the parents they lived with, including a parent outside the household (if parents were separated), grandparents, and parents' friends. A third of children spent regular time each week being cared for by other people; 68% were cared for only by the focus nursery and their parents at home. Again, parents were asked to obtain the relevant information from other caregivers and to complete the diary accordingly, so that any variation between caregivers or settings would be documented.

Some children spent longer periods of time with other caregivers in other households. This included regular overnight stays at other households for some children, mainly at the house of another parent (if parents were separated) or grandparents (see Table 5.18), and often without the parents they lived with.

Table 5.18: Frequency of Children Staying Overnight in Other Households

Frequency of Staying Overnight at Another House (without parents)	Frequency (%)
Less than once a month	58 (59)
Once night a month	14 (14)
One night a fortnight	11 (11)
One night a week or more	15 (15)

When children regularly slept in other households, or spent whole days in other households, most parents delayed the diary until their child was at home. In these cases, any variation in children's behaviours related to spending time in other households was not documented. In these circumstances, parents were sometimes unaware of what happened at these other households; parents often did not discuss children's sleep schedules, diet or routines with other caregivers, especially where children spent regular time with another parent (when parents were separated). This was upsetting for some parents, who felt unable to influence their children's behaviours and maintain routines when they were disrupted regularly and not maintained by other caregivers (see Chapter 6).

Therefore whilst typical behaviours and practices were the focus of this study, it should be noted that some children spent regular periods with other caregivers and in other households, and this may affect their habitual or typical behaviours and activities. Interviews were conducted with, and diaries completed by, parents with whom children lived most of time; therefore they document behaviours according to the main caregiver only. The frequency and degree of variation in children's behaviours and activities across different households is not captured in this study. Future research examining parents' attitudes and practices, and children's habitual sleep, food intake and activities, could examine the degree and impact of variation that children experience between households and caregivers.

Summary: Variability in Children's Behaviours

There was significant variation in children's sleep patterns and activities between week and weekend days; therefore, weighted means were calculated for further analyses. There was no significant variation in children's sleep, food intake and activities according to daylength, or timing of nursery session (morning versus afternoon). Season and nursery schedule were therefore not considered in further analyses.

This study explored children's typical behaviours, and their primary caregivers' typical practices. Any variation in children's behaviours due to special events, or due to staying in other households or being cared for by other caregivers, was not documented. The degree of any such variation, and any affect on research findings, cannot be determined.

Future studies could examine the degree and impact of variation in children's experiences in these scenarios.

Associations of Children's Sleep with Body Composition

This section of the chapter will examine associations between children's sleep and body composition. Analyses will include sleep as assessed over an extended period (including week and weekend days); daytime in addition to nighttime sleep duration; and waist circumference and skinfold thickness in addition to BMI. In doing so, this section will address secondary aims one and two.

Body Composition and Children's Sleep

The potential of sleep in early childhood to modify or prevent future obesity risk is of interest in this study; hence risk of obesity in later childhood and in adulthood, rather than concurrently at age 3 years, is the primary focus. However, sleep duration has been found to be associated cross-sectionally with obesity in children as young as 4-years-old (Anderson & Whitaker, 2010), and Bayer et al. (2009) reported that the sleep-obesity association is similar in children from ages 3 to 10 years. Therefore, associations were examined between body composition and children's sleep (see Table 5.19).

Table 5.19: Associations of Children's Anthropometric SD Scores with Sleep

Pearson's Correlations, Spearman's Correlations	BMI SD Score	Waist Circumference SD Score	Triceps Skinfold SD Score	Subscapular Skinfold SD Score
Weighted Mean Bedtime (n=74)	r= .08	r= -.05	r= .07	r= .23
Weighted Mean Nighttime Sleep Duration (n=85)	r= -.11	r= -.01	r= -.02	r= -.20
Weighted Mean Daily Nap Duration (n=84)	r_s= -.02	r_s= .05	r_s= -.13	r_s= .03
Weighted Mean Total Daily Sleep Duration (n=84)	r= -.12	r= .01	r= .08	r= -.24 *

* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$

Bedtime, nighttime sleep duration and daily nap duration were not correlated with body composition. There was a significant negative correlation of total daily sleep duration with subscapular skinfold SD score, but not with BMI, waist circumference or triceps skinfold SD scores.

Since subscapular skinfold thickness is the most direct measure of centrally distributed fat used in this study, these results suggest that although overall size was not correlated with sleep, children who slept for less each day had more central adiposity. This is consistent with growing evidence suggesting the importance of specifically centrally distributed fat in the link between sleep and childhood obesity (see Chapter 3). The association of sleep with subscapular skinfold thickness in particular is important since central obesity is more strongly correlated with health problems than is peripheral or general obesity (Maffeis et al., 2001), including increased cardiovascular and metabolic risks in children (Li et al., 2006).

The association of total daily sleep duration with subscapular skinfold SD score highlights the importance of combining nighttime and daytime sleep for analyses. Nighttime sleep duration alone was not associated with body composition, nor was daytime sleep. These results add to the conflicting literature regarding daily sleep composition (nighttime and daytime) and associations with obesity. Agras et al. (2004) concluded that the difference in sleep duration between obese and normal weight children in their sample was due to napping, whilst Bell & Zimmerman (2010) found that nighttime sleep predicted subsequent obesity but napping had no effect: contrastingly, this study suggests that combined nighttime and daytime sleep is important in the relationship with obesity.

This study assessed sleep duration over a 5 night period, including both week and weekend days (weighted mean). This measure of sleep duration may more accurately reflect habitual sleep habits in children, compared to previous studies that have used single estimates of sleep, and have not accounted for night-to-night variability (see Chapter 2). Although these are strengths of the study, the exploratory design and lack of power calculations prevent firm conclusions from being drawn. These results suggest that it is important to include habitual night-to-night variability in sleep and total daily sleep duration (including daytime naps in addition to nighttime sleep), and additional body composition measures to BMI, when assessing the sleep-obesity relationship.

Further research should examine these associations in a larger sample using more rigorous statistical techniques.

Summary: Associations of Children's Sleep with Body Composition

Weighted mean total daily sleep duration was significantly negatively correlated with subscapular skinfold SD score. This highlights the potential importance of including more direct measures of body fat (rather than BMI alone) in sleep-obesity research, in addition to considering both daytime and nighttime sleep duration, and night-to-night variability in sleep (including both week and weekend sleep over an extended period, rather than a single estimate of sleep). Further research is needed in order for these associations to be confirmed.

Chapter 5 Summary: Participant Characteristics and Initial Analyses

This chapter described the characteristics of the participating nurseries, children and parents. Five nurseries participated in the study, with 109 families taking part (a response rate of 82%, which was similar across the deprived versus affluent areas, and between white British versus BME families). Compared to families recruited from affluent areas, the deprived group had a greater proportion of BME families, more crowded houses, more paternal unemployment, more single parent households, and younger mean maternal age. The proportion of overweight and obese children was lower in this sample compared to the national average. Body composition SD scores did not vary between children living in deprived versus affluent areas, but were higher in white British compared to BME children, possibly due to the low proportion of BME participants.

This chapter also presented some initial analyses. The diaries were validated against actigraphy for assessment of children's daily sleep duration (nighttime sleep onset and wake up times, and daily nap duration). There was significant variation in children's sleep-wake patterns and activities between week and weekend days; weighted means were therefore calculated for further analyses. There was no significant variation in children’s behaviours according to daylength, or timing of nursery session (morning versus afternoon), and so these variables were not considered in further analyses.

This chapter addressed secondary aims one and two by examining correlations between sleep and body composition using weighted mean sleep duration assessed over 4 days/5 nights; daytime, nighttime and total daily sleep durations; and waist circumference and subscapular skinfold in addition to BMI SD scores. Children’s weighted mean total daily sleep duration (but not nighttime or daytime sleep duration) was associated with subscapular skinfold SD score, which was the most direct measure of central adiposity. Further research should examine night-to-night variability in sleep, daytime, nighttime and total daily sleep, and direct measures of adiposity, in relation to the sleep-obesity link.

The following three chapters will explore children’s sleep, diet and activity behaviours, and parents’ attitudes and values. In doing so they will address the primary aims of this study.

Chapter 6: Sleep

This chapter will explore children's sleep, and parenting regarding child sleep. Specifically, this chapter will a) describe the sleep patterns of the children, b) examine associations of children's sleep with ethnicity and socio-demographic characteristics, c) discuss parents' attitudes towards their children's bedtime and sleep, and d) explore associations between parenting and children's sleep. In doing so, it will address secondary aim three, and begin to address primary aims two and three, for further investigation throughout the following chapters.

Children's Sleep-Wake Patterns

This section of the chapter will focus on the diary sleep-wake data. The patterns of and amount of daily sleep obtained by the children will be examined, and comparisons with reference data will be drawn.

Sleep-Wake Data

Descriptive sleep-wake data from the diaries are shown in Table 6.1.

Table 6.1: Diary Sleep-Wake Data: Descriptive Statistics for the Whole Sample

	n	Min	Max	Mean	SD	Median
Weighted Mean Bedtime (hh:mm)	74	18:17	22:58	19:48	00:53	19:38
Weighted Mean Sleep Start Time (hh:mm)	85	18:25	22:52	20:12	00:51	20:13
Weighted Mean Wake Up Time (hh:mm)	85	05:55	09:15	07:25	00:39	07:25
Weighted Mean Get Up Time (hh:mm)	85	05:55	09:27	07:33	00:42	07:33
Weighted Mean Sleep Onset Latency (mins)	59	1	105	25	22	17
Weighted Mean Nighttime Sleep Duration (mins)	85	552	761	673	38	674
Weighted Mean Daily Nap Duration (mins)	84	0	113	12	20	1
Weighted Mean Total Daily Sleep Duration (over 24 Hours) (mins)	84	601	767	682	35	681

Note: sleep onset latency is shown only for children who consistently fell asleep in bed

Associations between sleep-wake variables were examined (see Table 6.2) (for sleep onset latency and nap duration see below).

Table 6.2: Associations of Sleep-Wake Variables

Pearson's Correlations, r	Weighted Mean Total Daily Sleep Duration (n=84)	Weighted Mean Nighttime Sleep Duration (n=85)	Weighted Mean Get Up Time (n=85)	Weighted Mean Wake Time (n=85)	Weighted Mean Sleep Start Time (n=85)
Weighted Mean Bedtime	-.38 ***	-.56 ***	.67 ***	.66 ***	.91 ***
Weighted Mean Sleep Start Time	-.51 ***	-.66 ***	.67 ***	.68 ***	
Weighted Mean Wake Up Time	.23 *	0.1	.96 ***		
Weighted Mean Get Up Time	0.2	0.07			
Weighted Mean Nighttime Sleep Duration	.92 ***				
Weighted Mean Total Daily Sleep Duration					

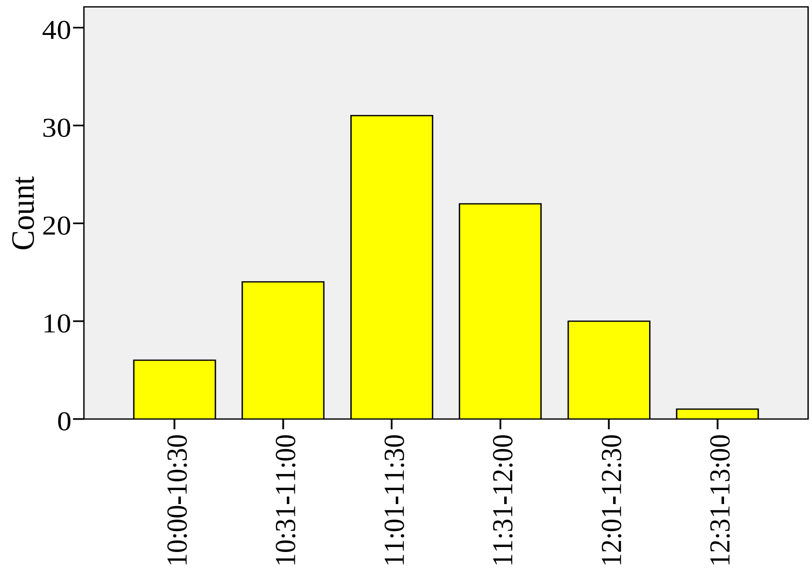
* p≤ .05 ** p≤ .01 *** p≤ .001

Bedtime and sleep start time were significantly negatively correlated with nighttime and total daily sleep durations, consistent with previous findings that late bedtimes contribute to short sleep (see Chapter 3). There were significant positive correlations between bedtime, sleep start time, wake up time and get up time. Wake up time was correlated with total daily sleep duration, but not with nighttime sleep duration.

Total Daily Sleep

The distribution of weighted mean total daily sleep duration (mean amount of sleep per 24 hours) is shown in Graph 6.1. Seventy-six percent of children slept for an average of between 11:00-11:30 hours in 24 hours. All children had daily sleep durations of more than 10 hours, whilst no children had 13 hours of daily sleep or more.

Graph 6.1: Distribution of Weighted Mean Total Daily Sleep Durations in the Children



Although there is limited understanding of sleep requirements in children, and a lack of definitive sleep durations deemed to be adequate or optimal for children (see Chapter 2), mean daily sleep duration in this sample was compared to the available reference data for preschool children (see Table 6.3).

Table 6.3: Total Daily Sleep Duration, and Reference Data for Preschool Children

Lead Author	Childrens' Nationality	Childrens' Age (Years)	Sample Size	Measure of Sleep	Total Daily Sleep Duration (hh:mm)
This Sample	British	3	84	Parent Diary	11:22
National Sleep Foundation	American	1-3	Recommendation		12:00-14:00
National Sleep Foundation	American	3-5	Recommendation		11:00-13:00
Iglowstein (2003)	Swiss	3	450	Parent Questionnaire	12:30
Sadeh (2009)	American & Canadian	2-3	700	Parent Questionnaire	11:54
Thorleifsdottir (2002)	Icelandic	2-3	70	Parent Diary & Questionnaire	11:20
Acebo (2005)	American	3	21	Parent Diary	11:40
Mindell (2010)	British	0-3	800	Parent Questionnaire	13:06

With the exception of the Icelandic data, sleep duration in this sample was consistently short compared to reference values. Although 76% of children in this sample achieved the sleep amount recommended by the American National Sleep Foundation for preschool children aged 3-5 years, mean sleep duration did not reach their recommendation for children aged 1-3 years: 86% of children in this sample slept for less than their recommendation of at least 12 hours. No children slept for longer than recommended for either age group.

The short sleep in this sample compared to reference data, in combination with the negative consequences of inadequate sleep (see Chapter 1), suggests that a substantial proportion of children in this sample may benefit from having longer sleep.

Daytime Napping

Around half of the children in this sample (51%) had at least one daytime nap documented in their diary. For children who had at least one nap, descriptive data for naps are shown in Table 6.4.

Table 6.4: Daytime Naps: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Weighted Mean Daily Nap Duration (mins) (Only Children who Napped)	45	1	113	24	23	21

Frequency and duration of napping in comparison to reference data for preschool children are shown in Table 6.5. The majority of children in reference populations still napped at age 3 years, and daily napping was between 1-2 hours in duration. In comparison, napping in children in this sample was consistently shorter, by 45 minutes or more per day; and with the exception of the Swiss reference data, the proportion of children who napped was at least 30% less. Even in comparison to whole-sample reference data (including non-nappers), daytime sleep in only children who napped in this sample was short.

Table 6.5: Daily Napping Duration for Just the Children who Napped, and Reference Data for Preschool Children

Lead Author	Children's Nationality	Children's Age (Years)	Sample Size	Measure of Sleep	Proportion of Children Napping (%)	Mean Daily Nap Duration (hh:mm) (Excluding Non-nappers)
This Sample	British	3	84	Parent Diary	51	00:24
Acebo (2005)	American	3	21	Parent Diary	81	01:10
Crosby (2005)	White American	3	171	Parent Questionnaire	80+	01:40
Iglowstein (2003)	Swiss	3	450	Parent Questionnaire	50	01:42
Weissbluth (1995)	American	3	172	Parent Questionnaire	92	02:06
					Whole Sample (Including Non-nappers)	
Mindell (2010)	British	0-3	800	Parent Questionnaire	02:37	
Sadeh (2009)	American & Canadian	2-3	700	Parent Questionnaire	00:53	

Daily Sleep Composition

Variation in composition of sleep over 24 hours may in part explain the shorter total daily sleep duration in this sample: compared to available reference values for preschool children, children in this sample achieved similar or longer nighttime sleep, but shorter daytime sleep, resulting in shorter total daily sleep duration (see Table 6.6).

Table 6.6: Daily Sleep Composition, and Reference Data for Preschool Children

Lead Author	Child Nationality	Child Age (Years)	Sample Size	Measure	Nighttime Sleep Duration (hh:mm) (Whole Sample)	Daytime Sleep Duration (hh:mm) (Excluding Non-Nappers)	Total Daily Sleep Duration (hh:mm) (Whole Sample)
This Sample	British	3	84	Parent Diary	11:13	00:24	11:22
Acebo (2005)	American	3	21	Parent Diary	10:30	01:10	11:27
Crosby (2005)	White American	3	171	Parent Questionnaire	10:20	01:40	11:45
Iglow-stein (2003)	Swiss	3	450	Parent Questionnaire	11:24	01:42	12:30
Mindell (2010)	British	0-3	800	Parent Questionnaire	10:31	02:37	13:06
Sadeh (2009)	American & Canadian	2-3	700	Parent Questionnaire	10:00	01:53	11:54

Associations of daily nap duration with bedtime, nighttime sleep duration and total daily sleep duration are shown in Table 6.7.

Table 6.7: Associations of Daytime Napping Duration with Bedtime and Sleep Durations

Spearman's Correlations, r_s	Weighted Mean Daily Nap Duration (n=84)
Weighted Mean Bed Time	.45 ***
Weighted Mean Nighttime Sleep Duration	-.25 *
Weighted Mean Total Daily Sleep Duration	.05

* $p \leq .05$ ** $p \leq .01$ *** $p \leq .001$

Duration of naps was correlated with bedtime. There was an inverse correlation with nighttime but not total daily sleep duration, suggesting that reduced nighttime sleep duration in nappers was compensated for by daytime sleep, ensuring that total sleep duration did not vary significantly. This is consistent with Acebo et al.'s (1995) finding that children with longer naps slept for less at night; and with Ward et al.'s (2008b) report that nighttime sleep was shorter for preschool nappers compared to non-nappers, but that total daily sleep duration did not vary.

Of those children who napped, two napped on all four days of the diary period. The others napped on only some days: their likelihood of napping did not co-vary with nighttime sleep duration on the previous or following nights (sleep duration on the night before a nap did not vary to sleep duration on the night following a nap; data not shown, $p>.05$). Whether short nighttime sleep results in napping, or whether napping results in short nighttime sleep, can therefore not be ascertained from these data.

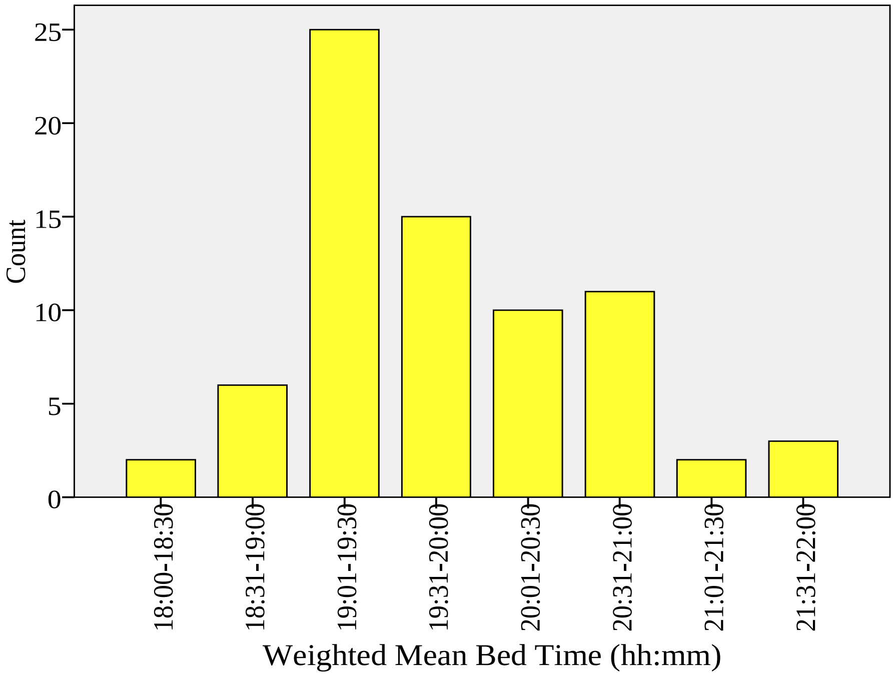
Whilst little is known about the benefits and consequences of consolidated nighttime sleep versus combined nighttime and daytime sleep for preschool children (see Chapter 2), children in this sample had less frequent and shorter napping, and shorter total daily sleep durations compared to reference data. The results suggest that short napping, in the absence of increased nighttime sleep, may result in insufficient total daily sleep; hence napping may be one way to increase total sleep duration in this population. This supports Ward et al.'s (2008b) proposal that an opportunity to nap could benefit most preschool children. However, Bell & Zimmerman (2010) reported that napping is not a substitute for nighttime sleep regarding obesity risk for preschool children, and so increased nighttime sleep rather than the introduction of napping may be more beneficial. Nighttime sleep, napping and total daily sleep were each considered separately in further analyses.

Bedtimes and Wake Up Times

The range between the earliest and latest weighted mean times across all children was greater for the time at which they got into bed (4:41 hours) than for the time at which they woke up for the day (3:20 hours) (see Table 6.1). The distribution of bedtimes is shown in Graph 6.2. Weighted mean bedtime was between 19:01-20:00 for 54% of children. Seven percent of children had a bedtime later than 21:00.

Whilst parents are able to directly influence the time at which their child goes to bed if they wish, in this sample 83% of parents said that they had no control over what time their child wakes up (see below). Therefore bedtimes are more directly under parental control and more vulnerable to modifications in parenting behaviours than are wake times.

Graph 6.2: Distribution of Weighted Mean Bedtimes in the Children



Furthermore, bedtime was significantly strongly correlated with both nighttime and total daily sleep duration, whilst wake up time was correlated with total daily sleep duration only. Previous studies have found bedtime to be a strong predictor of sleep duration and of weight status, and have proposed that short sleep duration is mainly attributable to late bedtime rather than early wake up time (Chapter 3).

Since sleep start times, wake up and get up times were significantly correlated with bedtime (Table 6.2), bedtime was more varied and directly influenced by parenting behaviours than were other sleep-wake variables, and bedtime was strongly correlated with all measures of sleep duration, bedtime and not sleep start time, wake or get up time were considered in further analyses.

Range in Bedtimes

Regular bedtimes have a positive influence on sleep (see Chapter 3), and irregularity of sleep has been associated with obesity (Chapter 2, Spruyt et al., 2011). In this sample, the individual range between earliest and latest bedtimes across the 5 diary nights varied between children from 0 to 240 minutes (see Table 6.8).

Table 6.8: Range in Bedtimes: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Range In Bedtimes (mins)	73	0	240	70	47	60

Associations of range in bedtimes with other sleep variables are shown in Table 6.9. There was a significant positive correlation with daily nap duration, but no correlations with nighttime or total daily sleep: this does not support an association of regular bedtimes with longer sleep.

Table 6.9: Associations of Range in Bedtimes with Bedtime and Sleep Durations

Spearman's Correlations, r_s	Range in Bedtimes (mins) (n=73)
Weighted Mean Nighttime Sleep Duration	-.20
Weighted Mean Daily Nap Duration	.28 *
Weighted Mean Total Daily Sleep Duration	-.11

* p≤ .05   ** p≤ .01   *** p≤.001

Standard deviation in bedtimes was calculated and examined as another measure of variability, which is less affected by one outlying bedtime: standard deviation in bedtimes was also not significantly associated with nighttime or total daily sleep durations (data not shown, p>.05). Since variability in bedtimes across the 5 diary nights did not appear to vary with sleep duration in this sample, it was not considered in further analyses.

Sleep Onset Latency

Sleep onset latency (the time between going to bed and falling asleep) was only calculated for children who fell asleep in bed for each night in the diary, since it is not a meaningful sleep measure for children who fell asleep before they got into bed. Sleep onset latency was significantly negatively correlated with nighttime and total daily sleep durations, as well as positively correlated with bedtime (see Table 6.10). This suggests that children who went to bed later took longer to get to sleep, and slept for less.

Table 6.10: Associations of Sleep Onset Latency with Bedtime and Sleep Durations

Spearman's Correlations, r_s	Weighted Mean Sleep Onset Latency (Children who Consistently Fell Asleep in Bed) (n=59)
Weighted Mean Bedtime	.30 *
Weighted Mean Nighttime Sleep Duration	-.60 ***
Weighted Mean Total Daily Sleep Duration	-.61 ***

* p≤ .05 ** p≤ .01 *** p≤.001

Children are generally considered to have problematic sleep onset if they require more than 20 minutes to fall asleep at night (Owens et al., 2000). Sleep onset latency was more than 20 minutes for 41% of the children in this sample; however, this is an overestimate of the time that it took children to get to sleep, since it includes time that parents spent reading or talking to their children in bed before they attempted to sleep. Eighty nine percent of parents reported their child’s sleep onset to be unproblematic.

Night Wakings

Similarly to sleep onset, 87% of parents believed night wakings to be unproblematic for their children. Seventy four percent of children had at least one night waking reported in their diary, but mean number of night wakings was 1 or less per night for 87% of children. Duration of night wakings was generally short: a sample mean of 9 minutes spent awake per night (see Table 6.11). Of the children for whom durations of night wakings were reported, 90% woke for an average of less than 20 minutes per night. Mean nightly duration of wakings was not correlated with bedtime, wake up time, nighttime sleep duration or total daily sleep duration (results not shown, all p>.05).

Table 6.11: Night Wakings: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Mean Night Waking Duration per Night (mins)	56	0	120	9	20	1
Mean Night Waking Duration per Night (mins) (Only Children who Woke)	34	1	120	14	24	5

Sleep Problems

Although there are no clear definitions for childhood sleep problems (see Chapter 2), the characteristics of sleep onset latency and night wakings in this sample are unlikely to fulfil the general criteria of frequent, severe and chronic symptoms of bedtime resistance and night wakings (Mindell et al., 2006). Furthermore, the proportion of parents considering their children to sometimes have problems with sleep onset or night wakings (11% and 13% respectively) were low compared to the reported cross-cultural prevalence for parent-reported child sleep problems of 25% (Owens, 2005). Additionally, no children were being medically treated for sleep disorders. These results suggest that sleep problems were not prevalent in this population. Therefore, sleep onset latency times and night wakings were not a focus in further analyses.

This is appropriate for the aims of the study, in which sleep duration rather than sleep quality was a focus. Although it may have been more accurate to subtract duration of night wakings when calculating sleep duration, data on duration of night wakings was only available for 34 of the participants: due to the large amount of missing data, night wakings were not included in sleep duration analyses. This is consistent with the majority of previous sleep-obesity studies which have estimated sleep duration without accounting for night wakings.

Summary: Children's Sleep-Wake Patterns

Although there are no definitive sleep recommendations for children, sleep duration was short in this sample in comparison to reference data for preschool children. Variation in composition of daily sleep, specifically short daytime napping in the absence of extended nighttime sleep, may contribute to comparatively short daily sleep in this sample compared to reference populations. Bedtime, sleep start time, wake up time and get up time were significantly correlated together; bedtime was the most varied between participants, is more amenable to parental modification, and was correlated with both nighttime and total daily sleep duration; therefore bedtime was examined in further analyses. Range in bedtimes over the diary period was not correlated with children's sleep, and sleep problems (long sleep onset and night wakings) did not seem to be prevalent in this population: these variables were not considered in further analyses. In sum, the main sleep variables for further analyses were nighttime, daily nap and total daily sleep durations, and bedtime.

This section of the chapter addressed secondary aim three by providing a detailed examination of sleep patterns in a sample of preschool children. Sleep duration varied in comparison to the available reference data; further examination of sleep patterns in young children, in different populations, in addition to sleep patterns in children of different ages, is needed, before sleep need in children can be fully understood or determined.

Children's Sleep: Associations with Ethnicity and Socio-Demographic Characteristics

This section of the chapter will examine potential associations of children's sleep with ethnicity and SES. Additionally, associations of sleep with sleep location and birth order will be assessed, since sleep has previously been found to co-vary with these characteristics.

Ethnicity and Children's Sleep

Comparisons in sleep were made between white British and BME children (see Table 6.12).

Table 6.12: Comparisons in Children's Sleep with Ethnicity

Independent t-test, Mann Whitney U	White British (n=95)	BME (n=14)	Statistic	p value
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:41 (0:47)	21:08 (1:00)	t=-4.19	<.001
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	675 (35)	641 (58)	t=2.34	.021
Weighted Mean Daily Nap Duration (mins) (median (range))	0 (0-65)	39 (0-113)	U=96	.010
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	683 (35)	663 (32)	t=5.94	.157

White British children had significantly earlier bedtimes compared to BME children. They had shorter daily nap durations and longer nighttime sleep, resulting in no significant difference in total daily sleep compared to BME children. This demonstrates a difference in sleep patterning between ethnicities consistent with previous studies (see Chapter 2). Crosby et al. (2005) similarly found that in American 3-year-olds, white children had longer nighttime sleep, shorter daytime sleep, but similar total daily sleep compared to black children. Mindell et al.'s (2010) cross-cultural comparison of sleep in children aged 0-3 years also found children living in predominantly Caucasian countries to have significantly earlier bedtimes, longer nighttime sleep and shorter daytime sleep than those in predominantly Asian countries; contrastingly to this study, they additionally found a difference in total sleep time.

SES and Children's Sleep

Comparisons in sleep were made between children in deprived and affluent SES groups (see Table 6.13).

Table 6.13: Comparisons in Children's Sleep between SES Groups

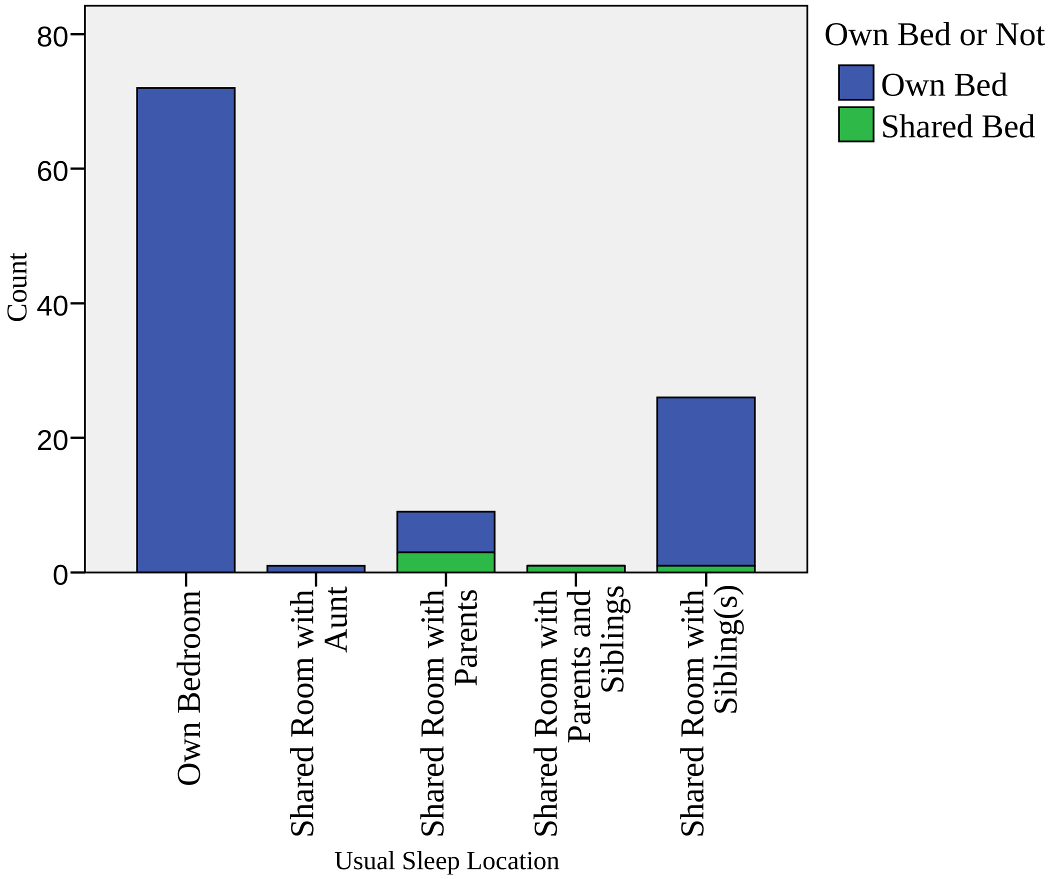
Independent t-test, Mann Whitney U	Affluent (n=49)	Deprived (n=60)	Statistic	p value
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:36 (0:34)	20:03 (1:06)	t=2.24	.028
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	677 (40)	668 (36)	t=-.99	.324
Weighted Mean Daily Nap Duration (mins) (median (range))	0 (0-59)	9 (0-113)	U=596	.006
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	682 (40)	682 (30)	t=.01	.995

Children living in affluent areas had significantly earlier bedtimes and shorter daily nap durations compared to those living in deprived areas. There were no significant differences in nighttime or total daily sleep durations. This adds to the conflicting literature regarding variation in children's sleep with socioeconomic variables (see Chapter 3).

Usual Sleep Location and Children's Sleep

Usual sleep locations for children in this sample are shown in Graph 6.3 (n=109). Nearly all of the children (95%) had their own bed; 4 children shared their parents' bed, and 1 shared a bed with his brother. The frequency of bedsharing with parents was less than Sadeh et al.'s (2009) report of 15% of US and Canadian children aged 24-36 months, whilst the proportion of children having their own bedroom (66%) was similar to their sample (67%).

Graph 6.3: Usual Sleep Locations of the Children



Sleep was compared between children who usually slept in a room of their own and those who usually shared a bedroom or a bed (see Table 6.14).

Table 6.14: Variation in Bedtime and Sleep Durations with Usual Sleep Location

Independent t-test, Mann-Whitney U	Sleep Location: Own Bedroom (n=66)	Sleep Location: Shared Bedroom or Bed (n=43)	t or U Statistic	p value
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:37 (0:37)	20:11 (1:11)	t= -2.68	.009
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	678 (37)	664 (38)	t=1.71	.092
Weighted Mean Daily Nap Duration (mins) (median (range))	0 (0-65)	9 (0-113)	U=681	.170
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	686 (37)	676 (31)	t=1.17	.247

Children who usually slept in a room of their own had significantly earlier bedtimes compared to those who did not. There were no significant differences in nighttime sleep, daytime nap or total daily sleep duration, despite previous reports of sleeping in a separate room being a strong predictor of nighttime sleep duration in preschool children (Sadeh et al., 2009). Therefore sleep location was not considered in further analyses involving sleep duration.

The location of each child's bed (own bedroom or shared) is likely to be influenced not only by parent or child preference (see below), but also SES and associated factors such as family size and household crowding. Grouping children who usually shared a bedroom into a single group did not distinguish between those who shared with siblings or with parents, but was necessary due to the low frequencies of children in these separate categories. Since parental presence at sleep onset is associated with sleep duration in children (see Chapter 3), distinction of children sharing a room specifically with their parents, or having their parents present at sleep onset, may have revealed associations with sleep duration.

Birth Order and Children's Sleep

Associations of birth order with children's sleep were assessed (see Table 6.15).

Table 6.15: Variation in Children's Sleep with Birth Order

Spearman's Correlations, r_s	Birth Order	p value
Weighted Mean Bedtime (hh:mm) (n=74)	r_s =.27	.019
Weighted Mean Nighttime Sleep Duration (mins) (n=85)	r_s =-.20	.073
Weighted Mean Daily Nap Duration (mins) (n=84)	r_s =-.02	.873
Weighted Mean Total Daily Sleep Duration (mins) (n=84)	r_s =-.21	.056

Birth order was significantly positively correlated with bedtime. This is contrary to Scher et al.'s (1995) finding that first-born Israeli children went to sleep later, and more in keeping with Rona et al.'s (1998) report of poorer sleep in British children whose birth orders were forth or more. Perhaps negotiation with later bedtimes of older siblings influenced children's bedtime, for example some parents delayed bedtimes of younger children to coordinate with those of older siblings (see below). Birth order was not significantly correlated with sleep duration variables, and so was not considered in analyses involving sleep duration.

Summary: Children's Sleep: Associations with Ethnicity and Socio-Demographic Characteristics

Bedtimes were significantly earlier for white British compared to BME children, children living in affluent rather than deprived areas, children who usually slept in a room of their own, and children with lower birth orders. Children living in affluent rather than deprived areas had shorter daily nap durations. Daily sleep composition varied with ethnicity, with white British children having shorter daytime sleep and longer nighttime sleep, but similar total daily sleep to BME children.

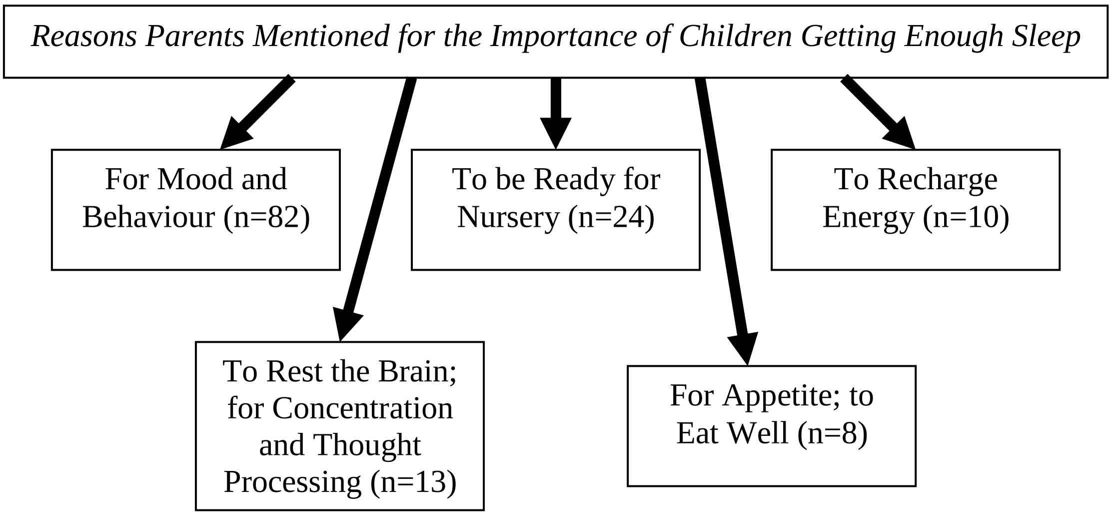
Parents' Attitudes and Behaviours Regarding Children's Sleep

This section of the chapter will focus on descriptions obtained during interviews, exploring parents' attitudes and practices regarding children's bedtime and sleep habits. Key topics will be discussed (including parents' knowledge, and scheduling and location of children's sleep), themes arising from the interviews will be identified, and parenting strategies regarding children's sleep will be investigated.

Parents' Knowledge of Child Sleep

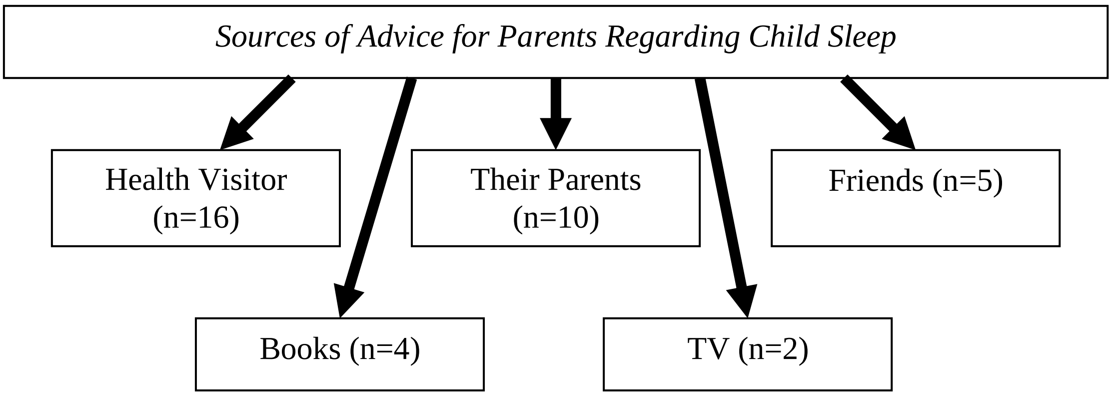
In this sample, the importance of adequate sleep for children was recognised by most parents. The most commonly mentioned reasons for the importance of sufficient sleep are reported in Figure 6.1. Notably, the reported benefits were all short-term. Preventing obesity was not mentioned by any parents as a reason for the importance of sufficient sleep, although 8 parents described their children not eating as well if they were tired (see Chapter 8 for a discussion of sleep and appetite).

Figure 6.1: Parentally-Reported Reasons for the Importance of Sufficient Child Sleep



In order to understand parents' practices and behaviours, it is important to consider when, where and how parents learn about sleep. Parents' knowledge and practices regarding sleep were mainly based on their own experiences. Twenty seven parents said that they had received advice regarding their children's sleep, whilst the remainder had not. Of those parents who had received advice, the sources are shown in Figure 6.2 (note that some parents reported multiple sources of advice).

Figure 6.2: Parentally-Reported Sources of Advice Regarding Child Sleep



Most information and knowledge was informal, provided by family and friends, rather than medically based. Sixteen parents had been given advice from their health visitor, but this was almost exclusively when their children were infants, with advice rarely being applicable to preschool children. One mother particularly mentioned the lack of readily available advice regarding preschool children's sleep:

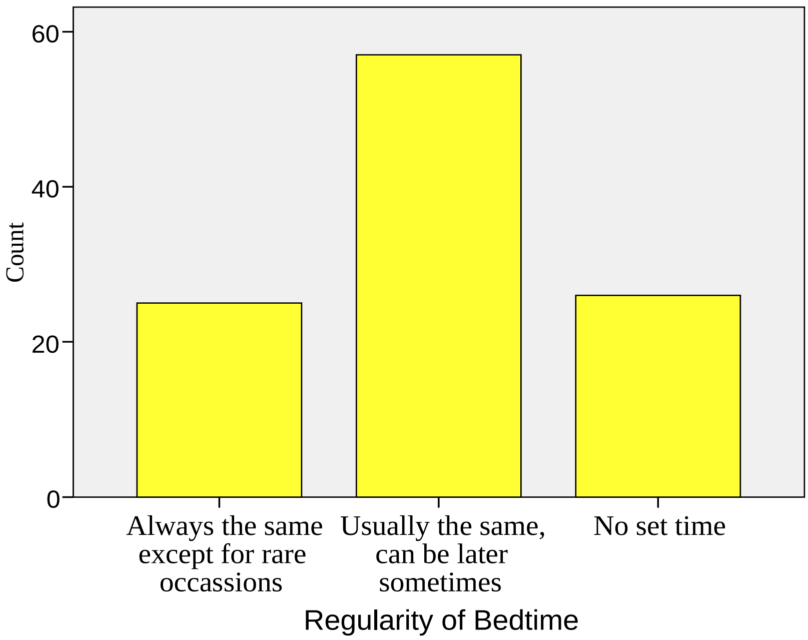
"When they're babies there's lots of information about what do, and advice from health visitors, but when they're 3 there's none." (ID 78)

Timing and Scheduling of Children's Sleep

a) Setting Regular Bedtimes

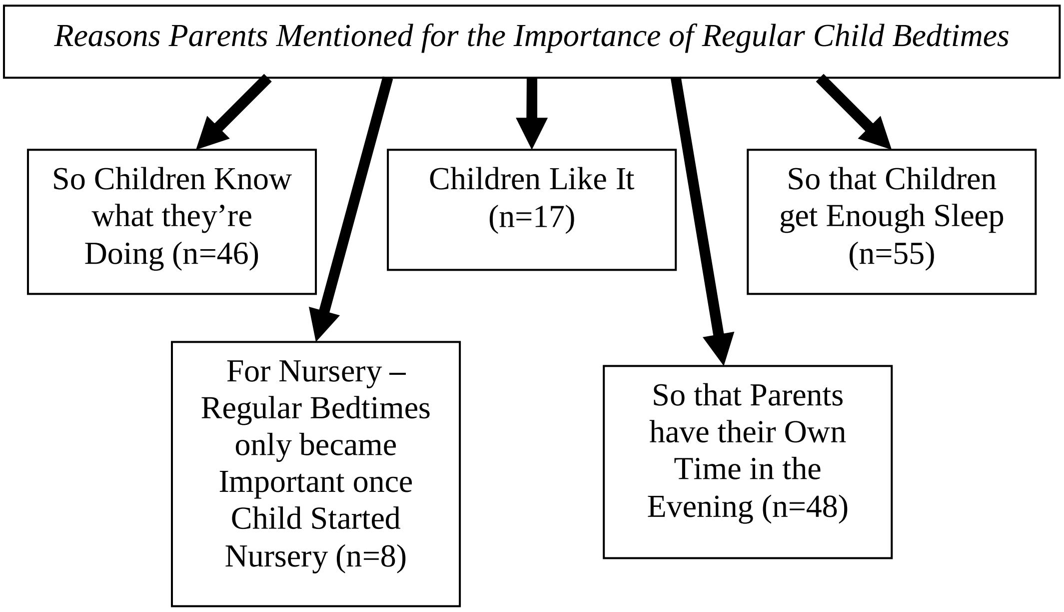
When parents discussed childrens' sleep patterns, the regularity of and degree of scope in bedtimes was a main topic. Parents' attitudes towards regularity of bedtimes varied from those who maintained consistent bedtimes every night (within a few minutes), to those who did not keep a bedtime at all (bedtime varied each night) (see Graph 6.4).

Graph 6.4: Parents' Attitudes towards Regularity of Child Bedtimes



Three quarters of parents (76%) said that their children's bedtimes were always or usually regular. The most frequently mentioned reasons for setting regular bedtimes are listed in Figure 6.3 (note that some parents reported multiple reasons).

Figure 6.3: Parentally-Reported Reasons why Regular Child Bedtimes are Important



The most commonly mentioned reason for keeping regular child bedtimes was to enable children to achieve sufficient sleep: this is in line with reports that regular bedtimes are important for children’s sufficient sleep (see Chapter 2). Parents also frequently mentioned that children like routine and consistency, and that regular bedtimes help them to feel secure and happy:

“I think it’s comfort, he seems to enjoy it.” (ID 4)

“Routine makes children feel secure.” (ID 29)

Having regular bedtimes, where children know what to expect and what time to go to bed, prevented bedtime resistance:

“She knows it's time to go to bed, and goes to sleep.” (ID 102)

“If they don’t know where they are and what they're doing you have more trouble getting them to bed and things.” (ID 92)

Allowing parents to have their own time in the evening is different to the other reasons in that it was beneficial for parents rather than for children:

“Is important so I [mum] have time for myself because the whole day is centred around them.” (ID 79)

However, many parents who mentioned this also listed reasons which benefitted their children. The perception of regular bedtimes benefitting both parents and children may be important when considering parental motivation for engaging in sleep regulation and routine-setting.

Of the parents who set regular bedtimes, two thirds allowed bedtime to sometimes be later, for example on weekend nights, holidays or special occasions. Allowing later bedtimes was frequently described by parents as a treat or reward for their children. Whilst regular bedtimes were more firmly adhered to during typical week nights, weekends were seen as a period when routines could be broken under special circumstances:

"We won't drag him home from a barbeque next door if it's a weekend, just for the sake of it being bedtime." (ID 107)

Family pressures led to bedtimes sometimes being later, for example parents' work schedules:

"When I'm [mum] working in the afternoon and back later, bedtime's a bit later." (ID 63)

"When their dad is working, he doesn't drive so I [mum] go to pick him up, and he [child] comes with me." (ID 78)

Another instance of household members' influences on children's bedtime regularity was the presence of siblings, and their scheduling constraints for sleeping and waking; hence bedtime regularity could vary for different children in the same family:

"There has to be more of a routine with him [compared to his older brother when he was aged 3] because we have to be up at a certain time to take his older brother to school." (ID 66)

Family members outside the household could also disturb childrens' bedtime regularity:

"On a Monday they go to their grandma's for tea, so its later bedtime when they get back." (ID 101)

"When they've been with their dad [who is divorced from their mum], they don't come back 'til 7:30pm so bedtime's later." (ID 58)

Some children regularly stayed overnight in other households, which disrupted bedtime routines and regularity. These overnight stays could be frequent, for example staying 3 nights each week with grandparents (ID 2). In these cases, parents expected at least some variation in bedtime to occur, and this was usually negatively perceived. Overnight stays with parents who were separated were considered particularly upsetting and disruptive, since parents' lack of awareness of or ability to influence their child's bedtime behaviours in this other household was particularly likely. At one extreme, a mother was taking legal action to enforce her daughter's father to follow her parenting rules when she stayed with him, in particular bedtime (ID 77).

In each of the scenarios described above, whilst bedtimes sometimes varied, they were regular for most of the time. Contrastingly, almost a quarter of parents (23%) did not set consistent bedtimes any of the time: they did not intend to bedtimes to be regular. Some of these parents did not consider regular bedtimes to be necessary:

"A kid'll know when they're tired, when they're tired they'll go to sleep." (ID 16)

"It depends how she feels, she goes when she's tired." (ID 16)

Others recognised that regular bedtimes were desirable, but felt either a) unable to implement them:

"Sleep's up to children - if they're tired they go to sleep, if they're not, what can you do?" (ID 21)

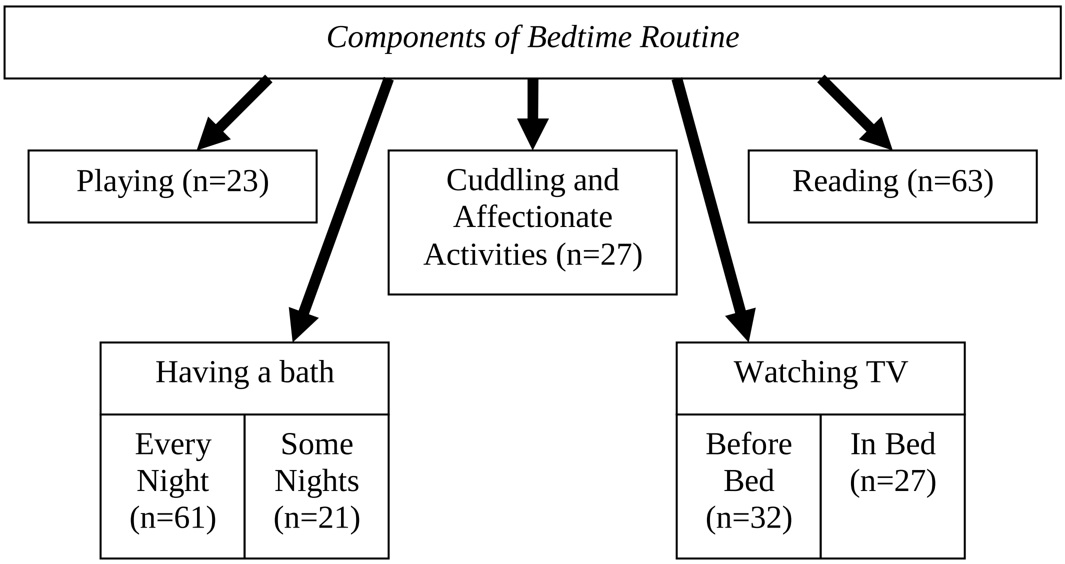
Or b) unwilling to implement them, mainly because it interfered with their own preferred schedules or desire to go out in the evening:

"I [mum] don't think my life or my husband's life should be dictated by childrens routine, if we want to do something we do and he comes along and goes to bed when he gets in." (ID 103)

b) Components of Bedtime Routines

The term "routine" was used synonymously by parents to mean "regular bedtime." However, the idea of a bedtime routine as a set of activities which occurred each night before sleep was distinct from a regular bedtime. Whilst a quarter of parents did not keep a regular bedtime, parents almost invariably reported that their child had a bedtime routine. This is in accordance with previous reports that the majority of preschoolers have bedtime routines (for example 93% of American preschoolers, Mindell et al., 2009a; 80% of UK 0-3 year-olds, Mindell et al., 2010). Parents' descriptions of bedtime routines varied from giving their children a kiss each night before they went to sleep, to a timed set of activities beginning with the evening meal. Commonly reported components of bedtime routines are reported in Figure 6.4.

Figure 6.4: Frequently Reported Components of Children's Bedtime Routines



Fifty eight percent of parents usually read to or with their children at bedtime, either just before they got into bed or in bed, which is comparable to the 58% of preschoolers in Mindell et al.'s (2009a) American sample who were read to as part of their bedtime routine. Reading at bedtime was enjoyed by both parents and children, and was sometimes used as a treat or reward:

"If she's been good in the day I [mum] might read her more." (ID 39)

Parents' enjoyment of reading to or with children mirrors the concept that bedtime has become an integral part of 'quality time' with children for some parents (Owens, 2004). Contrastingly, other parents negatively perceived the time and effort required, and it prevented them from engaging in reading at bedtime:

"We don't want children to drive us [parents: their children want stories every night]." (ID 36)

Twenty nine percent of children watched TV as part of their bedtime routine before getting into bed, and a further 25% watched TV or DVDs in bed. (See Chapter 7 for a discussion of children having TVs in their bedroom.) This exceeds the 11% of 3-year-old American children in Hale et al.'s (2009) sample for whom watching TV was a component of their bedtime routine, and is concerning due to the negative correlations between watching TV before bed and children's sleep duration and quality (Chapter 3).

Whilst reading requires parents' presence and input, most of the children who watched TV in bed did so without their parents being present; indeed, allowing children to watch TV in bed was sometimes described by parents as a method to reduce their involvement at bedtime.

c) Timing of Bedtime

Further to the setting (or not) of routines and regular bedtimes was the issue of what time children with a regular bedtime were sent to or taken to bed. When describing decision-making regarding their children's bedtime, no parents mentioned formal advice or guidance. Two main themes emerged: 1) many parents felt that it just comes to them:

> *"Bedtime is just more of a natural thing I think."* (ID 59)

And 2) parents frequently mentioned that they followed what their friends or family did:

> *"Speak to friends and see what their kids are like."* (ID 90)

Timing of bedtime was influenced to some extent by external and family factors, similarly to regularity of bedtime[3], including parents' work schedules:

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[3] ***Children's Sleep Schedules in Family Context***

Parents' decision-making regarding childrens' sleep-wake schedules did not occur in isolation, but in the context of the schedules and demands of other members of the household. Thus there were constraints on parents' abilities to schedule children's sleep as they deemed appropriate. For example, regularity and timing of bedtime were influenced by parents' work schedules, and the presence of siblings. Relatives outside the main household were also influential for children's sleep patterning: regular visits with members of extended family could delay bedtimes, whilst custody rights of a separated parent could disrupt bedtime regularity. It is therefore important to consider parents' behaviours regarding their children's sleep patterns not in isolation, but within the wider context of the whole family, and to understand the set of constraints under which they work.

"He [dad] doesn't get in from work until 6:30pm. He likes to see them and read a story; then he puts them to bed." (ID 61)

The presence of either older or younger siblings could influence bedtime to be earlier or later:

"We [parents] have to put the younger one [child] to bed first, then the older one." (ID 58)

"They both [child and his sister] go to bed at the same time, to stop them arguing. It's probably a bit late for him and early for his sister." (ID 63)

Some parents considered their own desired sleep-wake schedules when setting bedtimes for their children. Children's bedtimes were influenced in two directions: 1) parental desire to have their own time in the evening could drive bedtime to be earlier:

"If bedtime was any later then we [parents] wouldn't have much time in the evening." (ID 56)

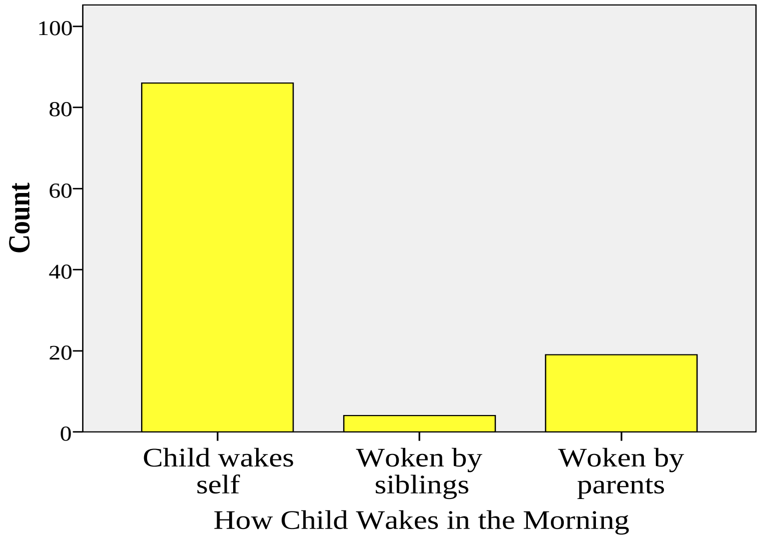
Or 2) bedtime could be delayed in an effort to maintain parentally preferred morning wake up times:

"If they go to bed any earlier, they're up earlier, which isn't good for us [parents]." (ID 51)

d) Wake Up Time

Most parents (83%) reported having no control over what time their children wake up for the day, whilst 17% said that they wake their children up in the morning (see Graph 6.5). Where parents reported waking their children up in the morning, this was usually on week days when parental work and child nursery schedules dictated the necessary time to get up. In most cases, parents described waking their children up and leaving them for a few minutes in bed, followed by children getting out of bed without resistance. Where children were woken up by their siblings, this was usually considered problematic by parents; for example younger or boisterous siblings disturbing the household and waking children up inappropriately early.

Graph 6.5: How Parents Described their Children Usually Waking Up in the Morning



Children spontaneously waking up for the day inappropriately early was most frequently reported for weekend days, when some parents wished to stay in bed for longer. Where parents wanted to stay in bed once their children had woken up, some parents banned their children from disturbing them. For example, one mother instructed to daughter to:

"Keep herself occupied and not annoy me." (ID 6)

She was to do this by watching cartoons and playing in her bedroom on her own until her mum was ready to get up. Another parent reported:

"We [parents] put a TV in his room because we thought he might stay in his room a bit longer." (ID 98)

A response by other parents to early child wake up times was to modify their own sleep-wake schedule so that they would also be awake early, to get up with their children. Sometimes negotiation between parents was reached, for example the mother would have a lie in at weekends, while the father got up and looked after and entertained the children.

Some parents encouraged their children to get into their (parents') bed on weekend mornings, so that they could stay in bed longer whilst supervising their children (note that this is distinct from children sleeping in their parents' bed throughout the night: see below). This enabled a compromise between child and parent sleep-wake preferences, and was usually considered a treat by children and parents alike:

“It's nice to have family time together all in bed.” (ID 51)

e) Appropriateness of Daytime Napping

As described above, daytime sleep in children in this sample was inversely correlated with nighttime sleep, resulting in similar total daily sleep duration for children who did and did not nap (Table 6.7). However, parents did not consciously perceive napping to be a method to increase or ensure adequate sleep in their children: indeed, 35 parents spontaneously commented that they tried to prevent their children from having naps (see Table 6.16).

Table 6.16: Parents’ Opinions and Behaviours Regarding Children’s Napping

Parents' Attitudes to Children’s Napping	Frequency (%)
Try to Prevent Naps	35 (35)
Allow Naps if Child Prefers	25 (25)
Encourage Naps	9 (9)
Unable to Answer - Child Does not Want Naps	31 (31)

Various methods were described by parents to try to prevent children from napping, such as giving them sweets and engaging them in activities. This may partly explain the short daytime napping in this sample compared to reference populations (see Table 6.3).

A major reason given by parents for trying to prevent their children from napping was that daytime napping would delay subsequent bedtimes, and decrease nighttime sleep. Weissbluth (1995) also reported a common reason for parents stopping children’s naps being so that they would go to sleep earlier at night (30% of his American sample). The significant correlation of daytime napping with bedtime in this sample (Table 6.7) supports parents’ concerns that napping delays their children’s bedtime. However, amongst children who napped on some days and not others, nighttime sleep duration was not shorter on nights following a nap compared to nights when there had not been a nap (see above): this knowledge may alleviate parental fears that nighttime sleep is adversely affected by daytime napping.

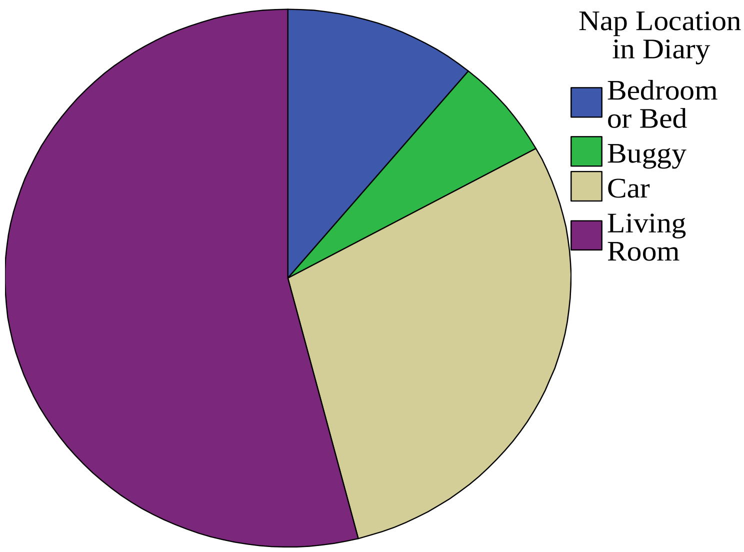
In the 9 parents who deliberately encouraged naps, the main reason was to prevent child moodiness in the absence of naps:

"If he didn't have a nap then he gets fidgety, boisterous." (ID 24)

Another 25 parents did not have an opinion regarding the appropriateness of children napping, and allowed them to do so if and when they wanted. Thirty one parents were unable to comment on their attitude towards napping since their children did not want naps.

Opportunistic, rather than planned or scheduled, was the main form of napping mentioned by parents: some parents reported that their children only nap occasionally in the car (n=24) or when he or she is ill (n=6); falling asleep in the living room whilst watching TV was also mentioned. Consistent with these interview descriptions, of all the naps reported in the diaries, 11% were reported as taking place in a bedroom or a bed (see Graph 6.6), with the majority taking place in other locations, most likely opportunistically.

Graph 6.6: Locations of the Naps Documented in the Diaries



In the diaries, two children napped on all four days and five children napped on three days. The majority napped on one or two days only. Some of the reported naps were very short: of the children who had at least one nap, 45% had a total of one hour or less over all four days; 28% had a total of more than two hours of naps over four days.

These inconsistent napping schedules support the notion that with the exception of the few longer and more consistent nappers, napping was mainly unplanned rather than a conscious strategy in this sample.

Sleep Location

f) Sleep Onset Location

Usual nightly sleep location for children was described above. When discussing nighttime sleep onset, some parents said that they ensure their children fall asleep in bed, whilst others reported their children to usually fall asleep in another location (for example in their parents' bed, on the sofa, in a buggy). Examination of the diary data revealed that the proportion of children who fell asleep in a location other than their own bed for at least one of the five nights was 37% (see Table 6.17). For the majority of this 37%, there was a combination of different locations within their own house, suggesting that constraints were not set by being in a different house, but rather parents did not put their children to bed in a consistent place within the house before they went to sleep. Notably, 9% of children were not reported to have fallen asleep in their own bed for any of the nights; these children mainly fell asleep in their parents' beds or on sofas.

Table 6.17: Consistency of Sleep Locations for the Children

Sleep Locations		Frequency (%)
Fell Asleep in the Same Location Each Night	Own Bed	52 (57)
	Parents Bed	3 (3)
	Sofa (Living Room)	2 (2)
Fell Asleep in Two Different Locations	Parents Bed and Sofa (Living Room)	2 (2)
	Own Bed and Parents Bed	4 (4)
	Own Bed and Sofa (Living Room)	10 (11)
	Own Bed and Grandparents' House	8 (9)
	Own Bed and Another House	2 (2)
Fell Asleep in Three Different Locations		8 (9)

Two of the parents who described their children regularly falling asleep outside of their own bed planned and preferred this: one girl fell asleep in her mothers' bed so that her mother could watch TV whilst supervising her falling asleep; once asleep, she was carried into her own bed (ID 2). Another girl was put into her pushchair at night so that her dad could stay downstairs and supervise her whilst she went to sleep (ID 28).

Falling asleep on the sofa was not planned by any parents. Where this did occur, it was sometimes driven by child preference for falling asleep in the living room and reluctance to go to bed:

"We [parents] used to let her fall asleep on settee whenever she wanted, telly on. She would scream if we moved her, so the whole family would sleep downstairs." (ID 9)

"I [mum] can see she is tired and suggest taking her to bed, she says she wants to fall asleep on the sofa." (ID 20)

Other commonly-described scenarios were parents' failure to take their children to bed before they fell asleep due to not being aware that they were falling asleep, or due to reluctance to spend time taking their children to bed either at the appropriate time, or at all:

"Sometimes she asks to go to bed, but I [mum] say wait until I've finished watching my programme; and then she'll fall asleep on sofa." (ID 19)

"Can't be bothered taking him, he may as well sleep on the sofa." (ID 44)

These descriptions imply that falling asleep on the sofa is opportunistic and spontaneous for children, rather than planned. This is consistent with the diary data, which showed that the majority of children who fell asleep on the sofa were inconsistent in sleep locations across different nights.

g) Sleep Location throughout the Night

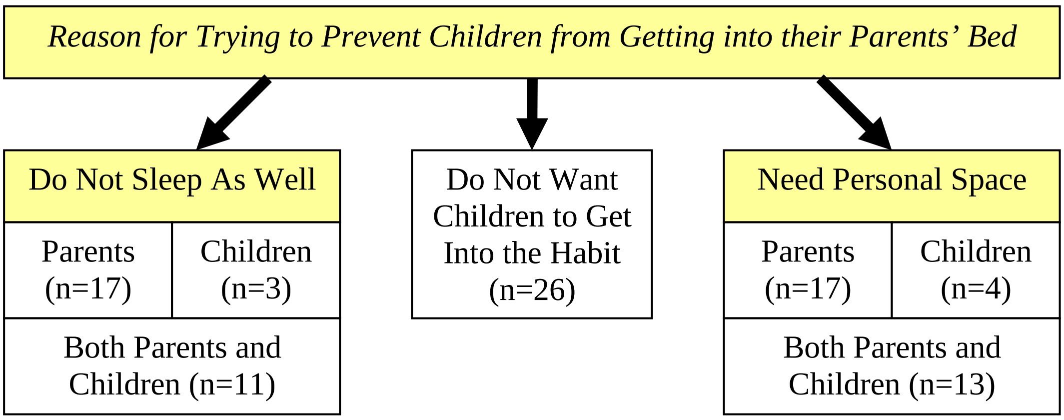
The issue of children sleeping in their parents' bed at night raised strong and opposing feelings in parents (note that this is distinct from children getting into their parents' bed in the morning once they were awake, which was discussed above; and this concerns typical nights, not exceptions, for example when children were ill). Four children routinely slept in their parents' bed throughout the entire night, as their usual sleep location. For one parent this was an undesirable necessity, due to access to only one bedroom (ID 11); for the others, bedsharing with their child was their preferred sleep arrangement.

Amongst other parents, opinion regarding their children sleeping in their bed at some point during the night varied. Some parents provided their children with their own bed, but were not opposed to them sharing the parents' bed for some nights or part of the night. However, the majority of parents (59%) reported that they try to prevent their children from sleeping in their bed at any point at night. Many parents felt strongly about this, and had been "*firm*" (ID 58) about it from an early stage:

> "*I [mum] was determined not to let them share my bed, from the offset.*" (ID 96)

Reasons for discouraging children from getting into their parents' bed are shown in Figure 6.5 (note that some parents reported multiple reasons). Figure 6.5 also documents who the reasons concern: parents, children, or both[4].

Figure 6.5: Commonly Reported Reasons for Parents Trying to Prevent their Children from Getting into their Bed at Night, and Who the Reason Concerns



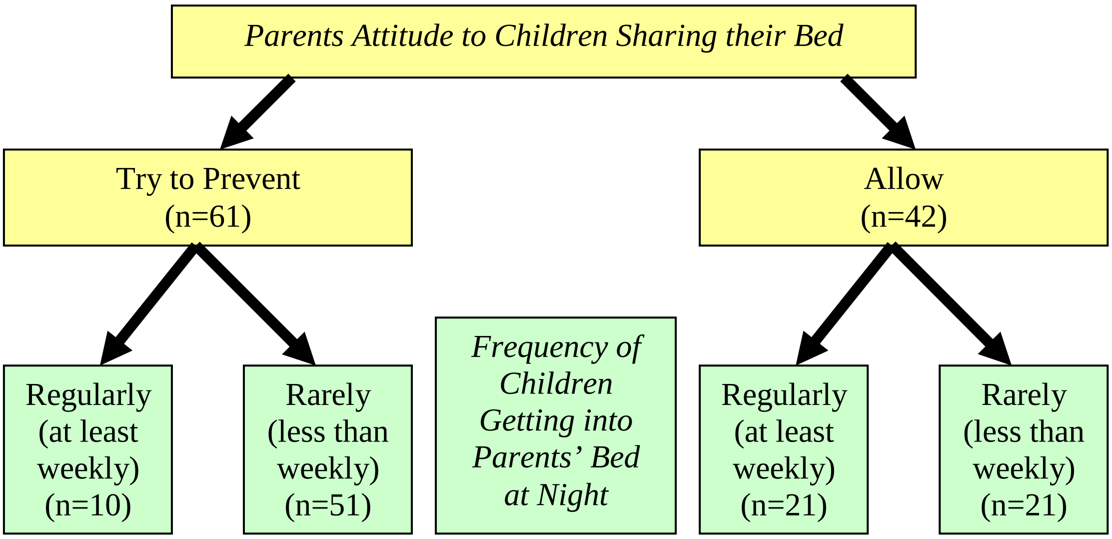
[4] ***Desire for Child Independence***
For some parents, desire for children to be able to initiate and maintain sleep independently was a driving force for setting bedtime routines, regular bedtimes, and preventing children falling asleep on the sofa or sleeping in their parents' bed. Frequently, parents described their attempts to limit their children's reliance on them for sleep, because they did not want to have to devote this effort and time every night:

"He has to learn that his parents can't be around all the time, has to learn to settle himself without us there." (ID 67)

Desire for child independence and self-soothing has previously been described in Westernised societies, where child autonomy and regulation are valued and aspired to (see Chapter 3).

Further to parents' attitudes towards children sharing their bed was the frequency at which children actually got into their parents' bed at night (see Figure 6.6). Twenty nine percent of parents said that their children regularly get into their bed during the night (at least once a week): this is a greater proportion than the 21% of US and Canadian children aged 24-36 months being brought into their parents' bed if they wake during the night, reported by Sadeh et al. (2009).

Figure 6.6: Children Getting into their Parents' Bed at Night: Parents' Attitudes, and Children's Frequency



Frequency of children getting into their parents' bed varied to parents' intentions because 1) some children were allowed to share their parents' bed but did not wish to do so, and 2) some children got into their parents' bed despite parents wanting to prevent this. Reasons for allowing children to sleep in their bed even when this was undesirable included children crying when they were put back in their bed after getting into their parents' bed, and parents worrying about waking other people in the house:

"We [parents] should stick to making her stay in her own bed, but we've got to think of waking her brothers if she cries." (ID 75)

Sometimes children got into their parents' bed without their parents waking up and realising:

"If it's really early we [parents] won't notice him get in, and if he's asleep we'll let him stay." (ID 78)

Commonly, parents described being too tired to put their children back to bed[5]:

"When we're [parents] tired from work, it's easier to let her stay in our bed when she gets in." (ID 51)

"We've [parents] always tried to keep them in their own beds. But when everyone's really shattered sometimes we give in." (ID 93)

"We're [parents] so tired it's the easiest option to let him stay there." (ID 47)

[5] ***Conflict and Negotiation of Parent and Child Sleep-Wake Schedules***
Parents frequently described conflicting and competing priorities for children's and parents' sleep-wake schedules. Regarding regularity of bedtime, this involved conflict between parents' preferences for themselves (wanting to be free to stay out later to socialise; wanting flexibility in schedules to fit in with other demands) versus for their children (maintaining a regular bedtime). Conflict in priorities were also revealed in timing of bed and wake up times: for example when parents wanted their own time in the evening but children did not want to go to bed; and when parents wanted to sleep for longer in the morning but children wanted to get up. For sleep location, conflict occurred when children wanted to fall asleep on the sofa or to get into their parents' bed at night, but parents wanted children to fall and stay asleep in their own bed.

Parents varied in their willingness to prioritise their own schedules and desires over their children's. Some parents insisted that they would not alter their children's sleep schedules for any occasion, for example describing how they leave social gatherings early in time for children's bedtime, and adjust their own sleep-wake schedules to conform to their children's desired wake up times. Other parents adapted children's bedtimes according to their own schedules and preferences, and stayed in bed once their children were awake if they so desired. At one extreme, one mother arranged for her daughter to stay with her grandparents every weekend so that she could maintain her own schedules and socialising at the weekend, uninterrupted (ID 14).

In some instances, parents' and children's schedules were in accord, for example when parents wished to set regular, early bedtimes for the benefit of their children and found that this also benefitted their desire for their own time in the evening. Sometimes parents negotiated schedules to strike a balance between child and parental preferences, for example encouraging children to get into their parents' bed on weekend mornings. Parents allowing children to sleep in their bed when this was not planned or desired could also be a method of bringing children's and parents' priorities in line with each other: where parents were tired, and children would not go back and sleep in their own bed without resistance and parental input, having children sleep in the parents' bed was deemed a successful way of allowing both parents and children to continue to sleep with minimum disruption. Hence strategies developed where parent and child needs and priorities were brought into accordance.

Parenting Strategies for Children's Sleep

Running throughout the topics described above (timing, scheduling and location of children's sleep) is the theme of parents' attitudes and practices regarding their role in children's sleep patterns. These behaviours and approaches to parenting can be broadly distinguished into two strategies:

- Strategy A: For each topic, there were examples of parents regulating their children's sleep: by setting regular bedtimes (always or usually, where possible); setting what they considered to be appropriately timed bedtimes; maintaining and promoting a bedtime routine involving parental input in the form of reading; either encouraging or preventing naps, as they deemed appropriate; ensuring that their children fell asleep in their own bed; and encouraging children to maintain sleep in their own bed throughout the night.

- Strategy B: For each topic there were also examples of parents enabling child choice: children could fall asleep when they wanted (which could be irregular times each night); where they wanted; their bedtime routines lacked activities requiring parental presence, such as reading, and often involved independent activities such as watching TV; children determined themselves whether or not they napped during the day; and they could get into their parents' bed during the night if they desired.

Parents' attitudes and behaviours regarding specific topics for children's sleep were categorised according to these strategies (see Table 6.18). Those behaviours listed under Strategy A reflect parents' use of regulation, consistency, limit setting, and prioritisation of childrens' sleep; as such, they are termed "routine-led" parenting behaviours. Those under Strategy B reflect child choice and self-governance of sleep, and inconsistency, and absence of parental regulation and limit-setting regarding sleep. As such, they are termed "routine-free" parenting behaviours.

Table 6.18: Parenting Behaviours Reflecting Different Strategies for Children's Sleep

Topic	Parenting Behaviours for Child Sleep	
	Parenting Strategy A: "Routine-Led"	Parenting Strategy B: "Routine-Free"
Setting Regular Bedtimes	Bedtime always or usually the same (n=82)	No set bedtime (n=26)
Composition of Bedtime Routine	Parent usually reads to/with child at bedtime (n=63)	Parent does not usually read to/with child at bedtime (n=42)
Sleep Onset Location	Child did not fall asleep on the sofa (n=68)	Child fell asleep on the sofa at least one night during the diary (n=21)
Sleep Location Through the Night	Child rarely gets into parents' bed (less than weekly) (n=77)	Child regularly gets into parents' bed (at least weekly) (n=31)

Associations amongst the parenting behaviours for each strategy were assessed (see Table 6.19).

Table 6.19: Associations of Parenting Behaviours for Children's Sleep

Chi-Square, X^2	*Sleep Location Throughout the Night*	*Sleep Onset Location*	*Composition of Bedtime Routine*
Setting Regular Bedtimes (bedtime always/usually the same versus no set time)	15.26 ***	21.97 ***	10.43 **
Composition of Bedtime Routine (parent usually does versus does not read at bedtime)	0.49	4.94 *	
Sleep Onset Location (child did not versus did fall asleep on the sofa during the diary period)	20.25 ***		

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

See Appendix J: Frequency Tables for Associations of Parenting Behaviours for Children's Sleep

Routine-led behaviours were significantly correlated together, whilst routine-free behaviours were significantly correlated together (with the exception of one correlation which was not significant). This clustering of routine-led and clustering of routine-free behaviours supports the idea that these are two distinct parenting strategies.

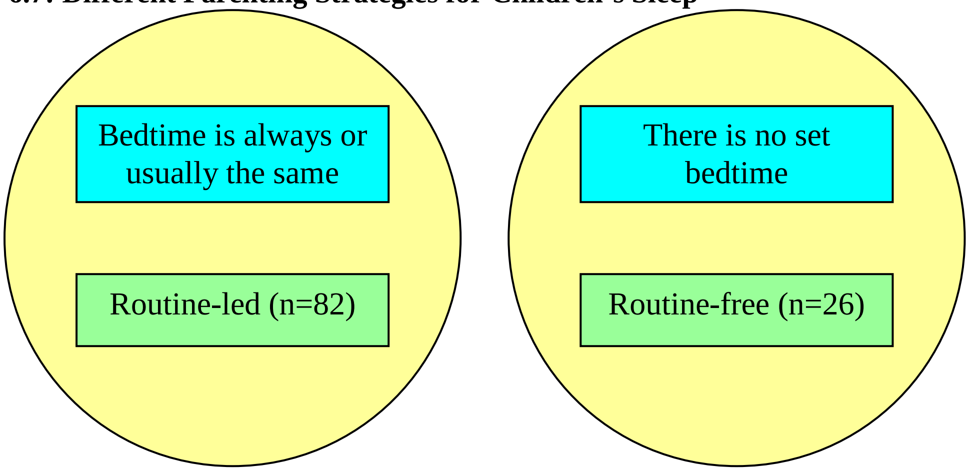
These different strategies may represent variation in parents' consideration of their role as parents. Routine-led parents considered it appropriate and necessary to actively regulate and promote their children's sleep, using routines and consistency, and enforcing limits. Routine-free parents did not consider it necessary or normal to regulate their children's sleep; instead, they allowed their children to determine their own sleep schedules, with minimal parental input. In some cases this may have been an active decision by parents to allow children to choose for themselves when and where to sleep, or to prioritise their own schedules over their children's; in others, this may be reflective of a laissez-faire attitude towards parenting, and lack of active decision-making regarding scheduling and routine for their children's sleep.

Since the parenting behaviours in each strategy are significantly correlated together, regularity of bedtime will be considered representative of parenting strategy for children's sleep: parents who set regular bedtimes (always or usually) will be considered routine-led, whilst those who did not set regular bedtimes will be considered routine-free for sleep.

Summary: Parents' Attitudes and Behaviours Regarding Children's Sleep

Parents varied in their attitudes and practices regarding the timing, scheduling and location of children's sleep. A general variation between parenting strategies was identified: "routine-led" parents regulated children's sleep, prioritising consistency, limit-setting and routines. "Routine-free" parents did not regulate children's sleep; hence it was child-governed and inconsistent. There was a clustering of routine-led parenting behaviours, and of routine-free parenting behaviours, lending support to their being distinct parenting strategies. Regularity of children's bedtime is representative of routine-led (bedtime always or usually the same) versus routine-free (no set bedtime) parenting strategies for children's sleep, as shown in Figure 6.7.

Figure 6.7: Different Parenting Strategies for Children's Sleep



Examination of Parenting Strategies for Children's Sleep

This section of the chapter will explore the parenting strategies for children's sleep identified above (routine-led and routine-free). Associations of parenting strategy with children's sleep will be investigated, and variation in parenting strategies with SES and ethnicity will be assessed.

Parenting Strategies for Sleep and Children's Sleep

Sleep was compared between children whose parents were routine-led versus routine-free for sleep (see Table 6.20). Compared to children of routine-free parents, children of routine-led parents had significantly earlier bedtimes, and longer sleep at night and over 24 hours.

Table 6.20: Comparison of Child Sleep with Parenting Strategy for Sleep

Independent t-test, Mann-Whitney U	Parenting Strategy Regarding Child Sleep		t or U value	p value
	Routine-Led (n=82)	Routine-Free (n=26)		
Bedtime (hh:mm)	19:39 (0:38)	20:32 (1:23)	t= -3.62	.001
Nighttime Sleep Duration (mins)	677 (33)	654 (48)	t= 2.38	.019
Daytime Sleep Duration (mins)	0 (0-65)	5.72 (0-113)	U=486	.241
Total Daily Sleep Duration (mins)	686 (32)	667 (41)	t= 2.02	.047

Notably, nap duration was longer in children of routine-free compared to routine-led parents, but this did not reach significance; the results suggest that decreased nighttime sleep duration in children with routine-free parents was not counteracted by increased daytime sleep, which resulted in reduced total daily sleep compared to children of routine-led parents. Total daily sleep duration was 19 minutes longer for children whose parents were routine-led compared to routine-free: over a week, this would result in 2:13 hours more sleep.

These results support previous findings (see Chapter 3) that parenting styles involving consistency and limit-setting are associated with children's sleep (termed laxness by Owens-Stively et al., 1997; hardiness by Johnson and McMahon, 2008; and vigilance by Meijer et al., 2001). Specifically, parental vigilance, hardiness, and absence of laxness, which are analogous to routine-led behaviours in this study, were associated with improved child sleep (longer sleep and earlier bedtimes, fewer sleep problems and less sleep disturbance, respectively). The results of this study extend the association of parenting styles with sleep to sleep duration in a group of non-sleep disordered British preschool children.

The association of routine-led parenting with longer children's sleep is also in keeping with previous documentation of the use of routines at bedtime being associated with longer (and less disturbed) sleep in preschoolers (Sadeh et al., 2009; Mindell et al., 2009a, 2009b). It is also consistent with Mindell et al.'s (2009a) suggestion that parents' reading at bedtime (a routine-led behaviour) is an indication of prioritisation and structure of children's sleep within the family, leading it to be positively associated with children's sleep.

SES and Parenting Strategy for Sleep

Frequencies of parenting strategies for children's sleep in each SES group were compared (see Table 6.21).

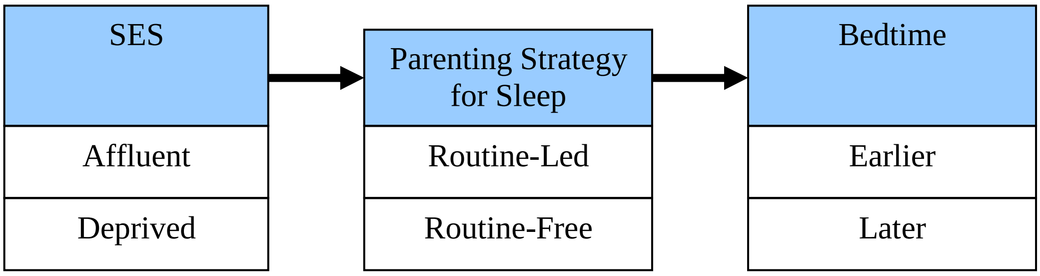
Table 6.21: Frequencies of Parenting Strategies for Sleep in each SES Group

	SES			
Parenting Strategy for Sleep	Affluent	Deprived	X^2	p value
Routine-Led (n)	43	39		
Routine-Free (n)	6	20	6.87	.012

Parents who were routine-led for children's sleep were significantly more likely to live in affluent areas, whilst routine-free parents were more likely to live in deprived areas.

Although causality cannot be determined in this study, it is not likely that parenting strategy causes parents to live in either affluent or deprived areas; rather, it is likely that SES influences parenting strategy. Since SES and parenting strategy are significantly associated, and both are correlated with bedtime (see Tables 6.13 and 6.20), there may be mediation between the variables, as shown in Figure 6.8.

Figure 6.8: Possible Mediation of the SES-Bedtime Association by Parenting Strategy



Parenting strategy was significantly correlated with nighttime and total daily sleep duration whereas SES was not, indicating that parenting strategy was associated with sleep duration independently of SES. However, the results presented here, in combination with the literature reviewed in Chapters 2 and 3, suggest that an association of SES with children's sleep, and a role of parenting, is feasible, and further investigation is needed.

Ethnicity and Parenting Strategy for Sleep

Frequencies of parenting strategies for children's sleep in each ethnic group were examined (see Table 6.22).

Table 6.22: Frequencies of Parenting Strategies for Sleep with Ethnicity

	Ethnicity	
Parenting Strategy for Child Sleep	White British	BME
Routine-Led (n)	74	8
Routine-Free (n)	20	6

25% cells have expected count less than 5, so statistical associations cannot be performed

The number of BME families was too small for statistical comparisons to be made, but the higher proportion of routine-free parents in the BME compared to white British group suggests that there may be variation in parenting strategies with ethnicity. Ethnic variation in routines and parenting behaviours have previously been reported for other aspects of children's sleep, particularly bed-sharing with parents (see Chapter 3). Future research into ethnic variation in parents' attitudes and behaviours regarding children's sleep is needed, as this may aid understanding of 1) the causes of parenting attitudes and strategies regarding sleep, 2) the influence of parenting attitudes on children's sleep, and 3) variation in children's sleep patterns with ethnicity.

Summary: Examination of Parenting Strategies for Children's Sleep

Children of routine-led parents had earlier bedtimes, longer nighttime sleep and longer total daily sleep duration compared to children of routine-free parents; this supports a positive association of regulatory parenting and routines with children's sleep. Routine-led parenting for children's sleep was more frequent in affluent areas, whilst routine-free parenting was more frequent in deprived areas.

Chapter 6 Summary: Sleep

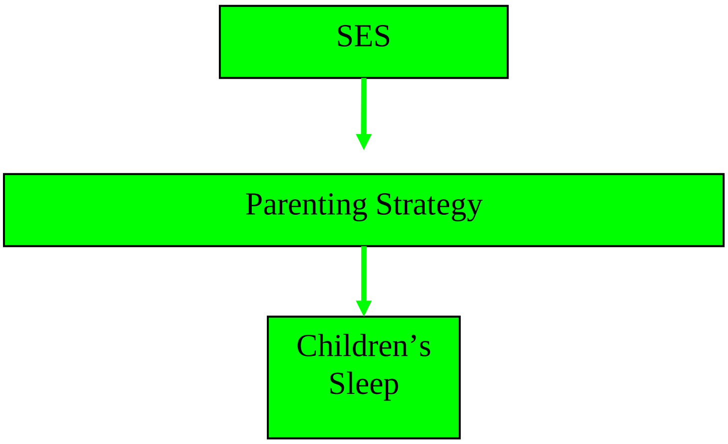
This chapter examined children's sleep patterns, parents' attitudes and practices regarding children's bedtime behaviours and sleep, and the associations of parenting with children's sleep. Examination of children's sleep patterns addressed secondary aim three; the results suggest that sleep is short in this sample compared to reference data for preschool children. Distinct parenting strategies were identified for children's sleep: these were termed routine-led versus routine-free. Routine-led parenting was positively associated with children's sleep duration compared to routine-free parenting, suggesting that parenting attitudes and behaviours are associated with children's sleep. Routine-led parenting for children's sleep was more frequent in affluent areas, and routine-free parenting was more frequent in deprived areas, suggesting a potential mediating role of parenting in associations of SES with children's sleep.

The exploratory and cross-sectional design of this study means that associations and direction of causality cannot be confirmed. However, based on the results presented in this chapter, in addition to the literature reviewed in Chapters 2 and 3, I have formulated Model A, as shown in Figure 6.9. This model will be expanded on and discussed in the following chapters, and will be interpreted using an evolutionary perspective in Chapter 9.

Figure 6.9: Model A

Children's sleep is influenced by parenting strategy (routine-led parenting is associated with longer children's sleep compared to routine-free parenting).

Parenting strategy mediates the relationship between SES and children's sleep (higher SES parents are more likely to be routine-led and lower SES parents are more likely to be routine-free; children in higher SES families are likely to sleep longer compared to those in lower SES families).



The next chapter will examine childrens' eating and activity patterns, with a similar focus on parents' attitudes and behaviours.

A Note about Naps

Nighttime, daytime and combined total daily sleep durations were analysed separately in this study. As described in Chapter 3, it is unknown whether consolidated nighttime sleep versus combined daytime and nighttime sleep has different effects on children's health and development. In this sample, it appeared that short nighttime sleep duration could be ameliorated by longer daily nap duration, resulting in similar total daily sleep duration for short nighttime sleepers who napped, compared to long nighttime sleepers (Table 6.7). Furthermore, the association of total daily sleep duration, and not nighttime or daytime sleep durations, with central fat (Chapter 5) suggests that the composition of sleep throughout the day is not important; rather, the total amount of sleep achieved is the influencing factor for body composition. Perhaps the negative effects of short nighttime sleep can be prevented or overcome if this is compensated for by longer daytime napping.

Although daytime napping may be beneficial, especially for children who have short nighttime sleep, napping was generally negatively perceived by parents in this sample: 35% of parents tried to prevent naps, compared to 9% who encouraged napping. I believe that napping for children in this sample was associated with lack of regulation and limit-setting by parents, and generally occurred when parents did not prevent it, due to a laissez-faire attitude. In support of this, although significance was not reached, mean daily nap duration was longer for children of routine-free compared to routine-led parents (Table 6.20).

Perhaps parents' attitudes prevented children from napping, when this would in fact be beneficial. Indeed, napping in this population was infrequent and short compared to reference data, which perhaps contributed to shorter total daily sleep duration in this sample compared to reference populations. Extending daily napping, by changing parents' perceptions of napping and encouraging parents to allow, or even schedule naps, rather than prevent them, may compensate for short sleep duration in this population. Future research should examine the ability to, and the effects of, extending daily nap duration in preschool children. Potential negative effects should be considered, particularly those which parents reported as important to them (including later sleep onset time and shorter nighttime sleep when children nap, although this was not supported in this study), in order to enable a balanced conclusion regarding napping.

Chapter 7: Diet and Activity

This chapter will explore children's diets and activity patterns (both physical and sedentary). There will be a particular focus on parents' behaviours and their associations with children's food intake and activities, and risk of obesity, in order to consider their possible role in the sleep-obesity link, thereby continuing to address primary aim two. Ethnicity and SES will be incorporated into analyses, and attitudes and values will be described in relation to parenting, thereby continuing to address primary aim three.

Children's Dietary Patterns

The first section of this chapter will explore children's food intake, and parents' attitudes and behaviours regarding their children's diets. Specifically, this section will a) describe the food intake of the children, b) examine associations of food intake with ethnicity, SES and body composition, c) discuss parents' attitudes towards mealtimes and their children's diets, and d) explore associations between parenting behaviours and children's food intake.

Servings of Food Groups

Mean daily number of servings recorded in the diaries for the key food groups defined in Chapter 4 are shown in Table 7.1. Although number of servings of these food items is a crude measure and does not account for size of portions, food which was left over, or quality of food and cooking, what is of interest here is the types of foods provided by parents or obtained by children, rather than the precise nutritional content of foods consumed.

Table 7.1: Food Groups: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Mean Daily Servings of Fruit & Vegetables	90	0	4.50	1.62	1.05	1.42
Mean Daily Servings of Pre Prepared Foods	89	0	3.00	1.20	0.71	1.00
Mean Daily Servings of Sweets	88	0	3.00	1.27	0.74	1.25

Notably, no children consumed the daily average of 5 portions of fruit and vegetables recommended by the WHO (2003). This is in accordance with previous findings of low fruit and vegetable consumption by UK children (Cooke et al., 2004).

Carbonated Drinks

Twenty seven percent of children were documented to have consumed at least one carbonated drink. Many other drink entries were described as “orange juice”: it was not possible to determine whether these were pure fruit juice or diluted juice, or whether they were sugar-free or sugar-sweetened. The designation of drinks as sugary versus non-sugary or as pure fruit juice is important, since specifically sugary and sweetened drinks have been associated with increased risk of obesity (Ludwig et al., 2001), whilst associations of fruit juice consumption with obesity have been less consistent (Dennison et al., 1997; Skinner et al., 1999; Alexy et al., 1999). Inability to define drinks such as “orange juice” in the diaries means that the consumption of these was not considered in further analyses. Therefore some carbonated or sugar-sweetened drinks may have been omitted from analyses.

Some parents did not list any drinks at all, even though they were instructed to so do, and so carbonated drink consumption for these children cannot be determined. Follow-up interviews upon diary completion would have enabled clarification of entries described as “juice”, and additional information to be obtained when no drinks had been entered, thereby overcoming these limitations.

Associations amongst Food Groups

Associations amongst servings of food groups and consumption of carbonated drinks are shown in Table 7.2.

Table 7.2: Associations amongst Servings of Different Food Groups

Spearman's Correlations r_s , *Mann-Whitney U*	Mean Daily Servings of Sweets (n=88)	Mean Daily Servings of Pre Prepared Foods (n=89)	Mean Daily Servings of Fruit & Vegetables (n=90)
Consumed Carbonated Drinks (Yes versus No)	U=566	U=351 **	U=574
Mean Daily Servings of Fruit & Vegetables	r_s=.22 *	r_s=-.35 ***	
Mean Daily Servings of Pre Prepared Foods	r_s=.04		

* p≤ .05 ** p≤ .01 *** p≤ .001

Number of daily servings of fruit and vegetables was significantly negatively correlated with daily servings of pre-prepared foods, and positively correlated with daily servings of sweets. Children who consumed at least one carbonated drink received more servings of pre-prepared foods per day (1.60±.72 versus 1.02±.68).

As discussed in Chapter 3, consumption of carbonated drinks, sweets and pre-prepared foods is likely to contribute to weight gain, whilst fruit and vegetable consumption is protective. The association of pre-prepared food servings with carbonated drink consumption and reduced fruit and vegetable consumption therefore represents clustering of intake of obesity-promoting foods. Contrastingly, servings of fruit and vegetables were positively associated with servings of sweets, resulting in obesity-protective and obesity-promoting foods being positively correlated. This may reflect the use of sweets as a reward for children eating fruits and vegetables (see below).

The dietary patterns here reflect those identified by North et al. (2000), who studied food consumption in the ALSPAC cohort (10,139 3-year-old British children) as recorded by maternal questionnaires. They identified which types of foods were eaten in combination, and identified 4 major dietary patterns. These included a “junk” diet, which was based on consumption of convenience foods and carbonated drinks; a “healthy” diet which included high salad and fruit intake; and a “snack group” which was based on consumption of puddings and cakes, and was also correlated with frequent consumption of fruit. These groups reflect the food patterns found in the current sample: servings of pre-prepared foods and carbonated drinks were associated together; servings of fruit and vegetables was distinct from pre-prepared foods and carbonated drinks; and consumption of sweets was positively associated with consumption of fruit and vegetables. The other group identified by North et al. was a “traditional” British diet comprising ‘meat and two veg’; this was not observed in the current study, which did not examine meat consumption.

Summary: Children’s Dietary Patterns

Mean daily servings of fruit and vegetables across the sample was 1.62, and no children received the recommended 5 daily portions. With the exception of sweets, servings of obesity-promoting foods were clustered together (pre-prepared foods and carbonated drinks) and were inversely associated with obesity-protecting food (fruit and vegetables).

Children’s Food Intake: Associations with Ethnicity, SES, and Body Composition

This section will examine potential associations of children’s food intake with ethnicity and SES. Additionally, correlations of food intake with children’s body composition will be explored.

Ethnicity and Children’s Food Intake

Comparisons in food intake were made between white British and BME children (see Table 7.3).

Table 7.3: Comparisons in Children’s Food Intake with Ethnicity

Independent t-test, Mann Whitney U, Chi-square	White British (n=95)	BME (n=14)	Statistic	p value
Daily Servings of Fruit & Vegetables (median (range))	1.5 (0-4.5)	1.0 (0-2.75)	U=208	.035
Daily Servings of Pre Prepared Foods (median (range))	1.0 (0-3)	1.0 (.75-2.5)	U=255	.318
Daily Servings of Sweets (mean (SD))	1.30 (.75)	.89 (.43)	t=1.41	.161
Carbonated Drinks Consumed (%)	25	50	X^2=1.77	.335

White British children received significantly more daily servings of fruit and vegetables compared to BME children. These results are in keeping with the higher intake of fruit reported for white compared to non-white British children aged 2-6 years (Cooke et al., 2004); but not with Northstone et al.'s (2005) description of a higher frequency of 'health-conscious' diets and lower frequency of 'junk' diets in non-white compared to white British preschool children. White and non-white categories are broad and undefined, and further examination of food intake in specific ethnic groups is needed.

SES and Children's Food Intake

Comparisons in food intake were made between children living in deprived and affluent areas (see Table 7.4).

Table 7.4: Comparisons in Children's Food Intake between SES Groups

Independent t-test, Mann Whitney U, Chi-square	Affluent (n=49)	Deprived (n=60)	Statistic	p value
Daily Servings of Fruit & Vegetables (median (range))	2 (0-4.5)	1.25 (0-3)	U=634	.002
Daily Servings of Pre Prepared Foods (median (range))	0.75 (0-2.5)	1.5 (0.5-3)	U=483	<.001
Daily Servings of Sweets (mean (SD))	1.32 (0.68)	1.22 (0.80)	t=-.64	.525
Carbonated Drinks Consumed (%)	15%	37%	X^2=4.96	.045

Children living in affluent areas had significantly more daily servings of fruit and vegetables, whilst children in deprived areas had more pre-prepared foods, and were more likely to have consumed carbonated drinks. This is consistent with previous documentations of SES variation in children's diets (see Chapter 3), specifically children in lower SES groups consuming fewer fruit and vegetables (James et al., 1997), and British 3-year-old children with less educated mothers (as in the deprived group) consuming more convenience foods and fewer fruit and vegetables (North et al., 2000).

Body Composition and Children's Food Intake

Associations between children's food intake and body composition were assessed (see Table 7.5).

Table 7.5: Associations of Anthropometric SD Scores with Servings of Food Types

Pearson's Correlations r, Spearman's Correlations r_s, *Independent t-test t*	BMI SD Score (n=101)	Waist Circumference SD Score (n=100)	Triceps Skinfold SD Score (n=98)	Subscapular Skinfold SD Score (n=96)
Mean Daily Servings of Fruit & Vegetables	r_s= -.13	r_s= -.04	r_s= .06	r_s= -.16
Mean Daily Servings of Pre Prepared Foods	r_s= .08	r_s= .06	r_s= -.14	r_s= .18
Mean Daily Servings of Sweets	r= -.13	r= .09	r <.01	r= .02
Consumed Carbonated Drinks (Yes versus No)	t= -2.01 *	t= -.77	t= -.56	t= -1.39

* p≤ .05 ** p≤ .01 *** p≤.001

BMI SD score was significantly higher in children who consumed carbonated drinks compared to those who did not (.70±.76 versus .25±.92). This is consistent with previous findings that intake of carbonated drinks and other sugar-sweetened drinks is associated with weight gain and obesity in children (Malik et al., 2006).

There were no other significant associations of body composition with dietary intake. This is not surprising given the inconsistency of data demonstrating dietary associates of obesity among preschool children (see Chapter 3). However, as described in Chapter 3, diets involving frequent consumption of pre-prepared foods and sweets, and low consumption of fruit and vegetables, are likely to result in excessive energy intake, which may contribute to excessive weight gain over time. Furthermore, tracking of these food intake patterns into later life may result in their association with future obesity risk (see Chapter 3). Hence the food groups identified, although not associated with current body composition and body weight, are likely to be associated with weight gain and future risk of obesity.

Summary: Children's Food Intake: Associations with Ethnicity, SES, and Body Composition

Children living in deprived areas had relatively obesity-promoting diets compared to those in affluent areas (more pre-prepared foods, higher frequency of consuming carbonated drinks, fewer fruit and vegetables). White British children received more fruit and vegetables compared to BME children. Children who consumed carbonated drinks had higher BMI SD scores compared to those who did not; there were no other variations in body composition with food intake, but patterns of energy intake and tracking of food intake patterns into later life mean that food intake in preschoolers is likely to impact on future body composition and risk of obesity.

Parents' Attitudes and Behaviours Regarding Children's Diets

This section will examine parents' descriptions, and explore parents' attitudes and practices regarding children's diets and mealtimes. Key topics will be discussed (including provision and restriction of food, and mealtime practices), themes arising from the interviews will be identified, and parenting strategies regarding children's diets will be investigated.

Parents' Regulation of Children's Diets and Food Intake

a) Encouragement of Consumption of Food Types

Some parents encouraged their children to consume foods which they perceived to be good for their health. Parents who prioritised "healthy" diets invariably considered these to include fruit and vegetables, and they generally preferred homemade meals, considering them to be more nutritious and wholesome compared to pre-prepared foods:

"I [mum] want his diet to be healthy, he has lots of fruit, no added salt or additives. If you instil these things in them he'll carry on eating well." (ID 67)

Thirty-four parents mentioned the importance of providing their children with a good diet since it is important for their health; a further 34 parents mentioned that they aim to provide fruit and vegetables for their children, but not specifically in relation to their health.

Parents who aimed to provide their children with "healthy" diets sometimes found their children reluctant to consume these foods. Various methods were described by parents to encourage their children to eat particularly fruit and vegetables. These included arrangement on the plate to make them appear attractive (for example arranged like a smiley face); hiding them with other foods which children liked so that they were not aware they were eating them (for example hiding vegetables with mashed potato, or putting them in sauce or gravy); bribery and reward[6]; and other methods:

"I've tried to get her to eat veg by doing lots of things – presenting it in different ways, eating with friends, letting her pick the veg." (ID 66)

Parents were sometimes restricted by the time and effort required for encouraging fruit and vegetable consumption:

"I [mum] have to coax him to make him eat veg. It takes time, and I have to take care of the baby so it's difficult." (ID 29)

Some parents felt powerless to encourage children to eat foods when they did not want to:

"You can't force children to eat." (ID 31)

Others did not want to, because they felt it to be inappropriate:

"I [mum] won't make her eat anything she doesn't like." (ID 21)

"Don't force a child to eat something they don't want, they don't like – I don't believe in that." (ID 32)

Where encouraging children to eat certain foods was not seen as appropriate or necessary, and a "healthy" diet was not prioritised, parents more commonly considered convenience, speed and preparation effort required when considering children's diets. This led to more frequent provision of pre-prepared meals for children whose parents did not encourage "healthy" diets, such as frozen meals and fast food:

"It's easier to put that in the oven than make something from scratch." (ID 6)

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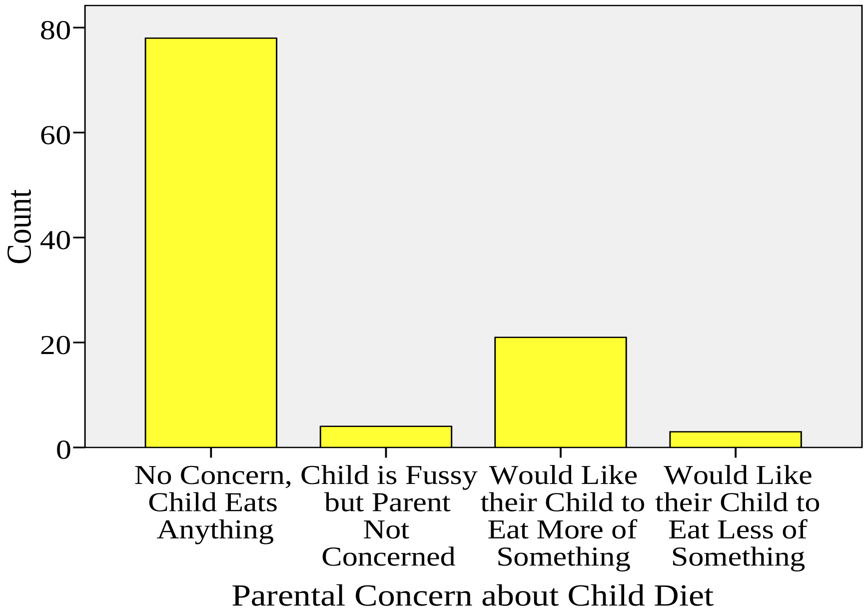
[6]***Food and Rewards***
Parents often described the use of "unhealthy" or snack foods, particularly sweets and desserts, as a reward for children consuming "healthy" foods, in particular fruit and vegetables. This may explain the positive association between consumption of fruit and vegetables and sweets (Table 7.2).

Parents also described using food (generally sweet snacks) as a reward for good behaviour. Hence there is a paradox of parents rewarding children's "good" behaviour with "bad" (obesity-promoting) foods. Parents thought that good children should not be deprived of food treats. Previous studies have also described mothers of preschool children perceiving food treats as an entitlement (Pagnini et al., 2007).

"I [mum] can't really be bothered cooking." (ID 84)

When discussing their children's food intake, 20% of parents described wanting their children to eat more of certain foods, including fruit and vegetables (see Graph 7.1). Despite fruit and vegetable consumption across the whole sample being low compared to national recommendations, the majority of parents were not concerned by low fruit and vegetable consumption.

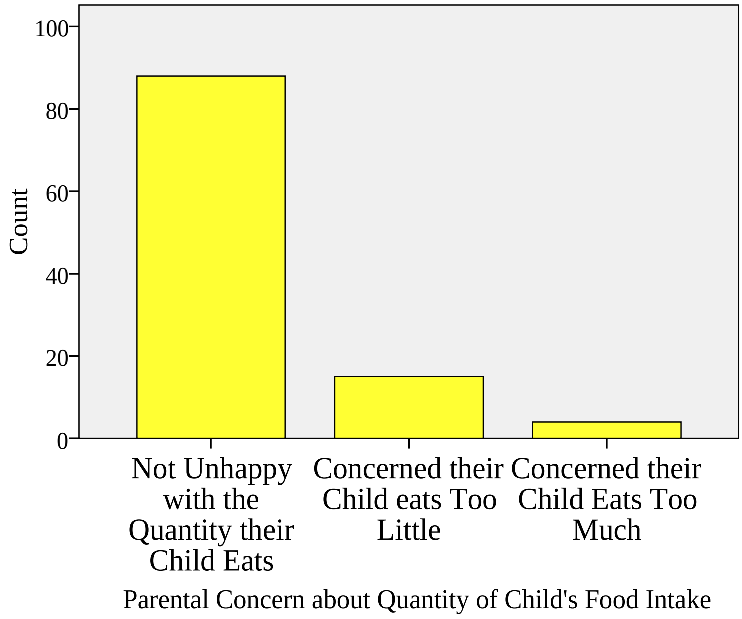
Graph 7.1: Parental Concerns about Children's Diet



b) Encouragement of Consumption of Food Quantity

Regarding the quantity of food which their children consume (rather than types of foods), 82% of parents were not unhappy or concerned (see Graph 7.2). Under-eating was a more common concern than over-eating, which supports previous findings of parents being more concerned about young children being underweight than overweight (Pegnini et al., 2007).

Graph 7.2: Parental Concerns about Quantity of Children's Food Intake



Where parents were concerned that their children did not eat enough, this was mainly when children would not eat at mealtimes. Various methods were reported for encouraging children to eat meals:

"We get teddy bears out, make like a picnic, sing songs." (ID 31)

"I [mum] leave his food on the table and he usually comes back… after a while." (ID 24)

"We [parents] try to encourage him to eat… we put the TV on because that way he'll eat." (ID 34)

In general, however, parents were not keen to "force" children to continue eating when they were full at mealtimes:

"If she's full she doesn't have to eat. I [mum] don't want her to be like myself and never want to leave any food on the plate. Don't want to get hung up on meals." (ID 62)

"Making them eat everything is like bullying." (ID 68)

Sometimes parents considered what their children had eaten throughout the day when deciding whether or not to encourage them to continue eating:

"She eats a lot of fruit so I'm [mum] not worried if she doesn't eat her whole plate." (ID 96)

"I [mum] think about what else he's eaten during the day, if he's had a good lunch it's not as bad if he won't eat his tea." (ID 48)

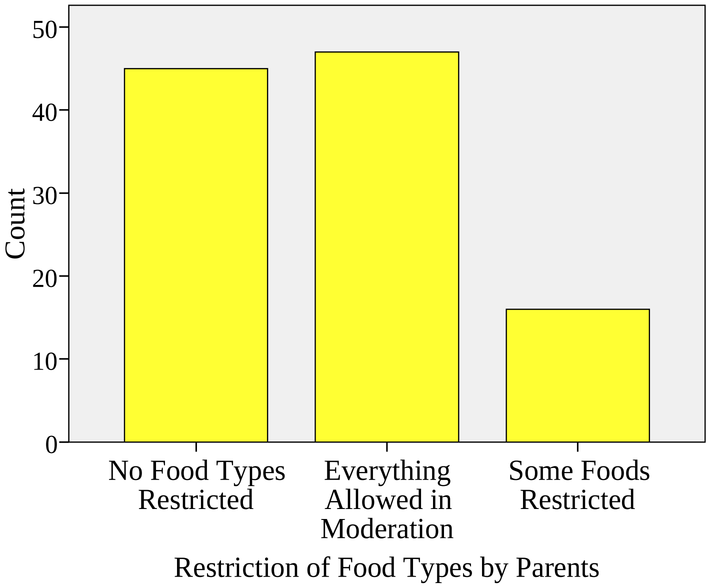
c) Restriction of Children's Food Intake

Whilst some parents encouraged their children to eat certain foods, parents more commonly reported restricting their children from eating certain foods. Restriction of carbonated drinks was most frequently mentioned, for reasons including the detrimental effects on teeth, and children becoming "hyper" after their consumption:

"She bounces around the room." (ID 6)

Compared to carbonated drinks, attitudes towards restriction of food types were more varied amongst parents (see Graph 7.3).

Graph 7.3: Parents' Restriction of Food Types



Some parents restricted certain foods totally. Others did not ban foods totally, but they limited consumption of certain foods, allowing them only in moderation. The types of foods restricted by both of these groups of parents were mainly sweets and biscuits, or other snack foods, due to adverse consequences for health:

"Sugar is bad for their teeth." (ID 32)

"I [mum] don't like her to eat too much rubbish. It can make her hyper, and her teeth, and it's not good for her skin." (ID 99)

"I'm [mum] worried he could become overweight when he's older… I keep an eye on what he eats." (ID 29)

"I [mum] restrict sugary snacks 'cause they make the children hyper, and I can't deal with that." (ID 39)

Often, sweets and snacks were used as treats by other relatives when children visited them[7]; parents were sometimes unhappy about this, since it undermined their efforts to regulate their children's diets.

Some parents restricted foods at certain times, allowing them only at specific times of the day or week:

"Sugary sweets are for the afternoon not the evening." (ID 6)

"I [mum] don't stop them from having treats altogether 'cause then they'd crave them more, but they can only have them on weekends." (ID 72)

[7] ***Impact of Other Households on Children's Dietary Regulation***
Regulation of children's diets was often broken when children visited other households, particularly without their parents' supervision. When children visited relatives, their diets were generally less restricted than at home, because relatives wanted to treat them:

"If he goes to his grandparents he has more sweets than he would at home, 'cause his granddad gives him them." (ID 57)

Often parents were unhappy about this, because they felt that eating restricted and usually sugary foods made children bad-tempered and hyperactive when they returned home:

"I [mum] don't like my mum or grandma giving him lots of sweets or biscuits – it's me who has to deal with her when she's hyper." (ID 6)

Snacking in other households also prevented children from eating what their parents wanted them to:

"She [child's aunt] lets them get away with stuff – she lets them graze all day. They have those and then won't be hungry to eat at meals. It's not structured. But with us [parents] it's structured." (ID 69)

Some parents tried to enforce dietary rules when their children visited other households, by asking relatives to restrict the same foods; but they were often not maintained, and parents felt powerless to change this. Other parents did not feel it appropriate to enforce rules in other households:

"'Cause they're [child's grandparents] good enough to look after her, I [mum] don't feel I can dictate what they give her to eat." (ID 66)

Some parents rewarded consumption of "healthy" foods, or good behaviour throughout the day, with sweet desserts or snacks. Others did not restrict foods so long as the "healthy" foods were consumed:

"As long as he eats his fruit and veg he can eat anything else." (ID 100)

For 42% of children, there were no restrictions on foods at all: all foods were allowed in any quantity (in some cases this meant as long as they conformed to the foods and preparation techniques acceptable within their religious group). Some parents did not consider it to be appropriate to restrict food from children:

"I'd [mum] never say no to him where food is concerned." (ID 27)

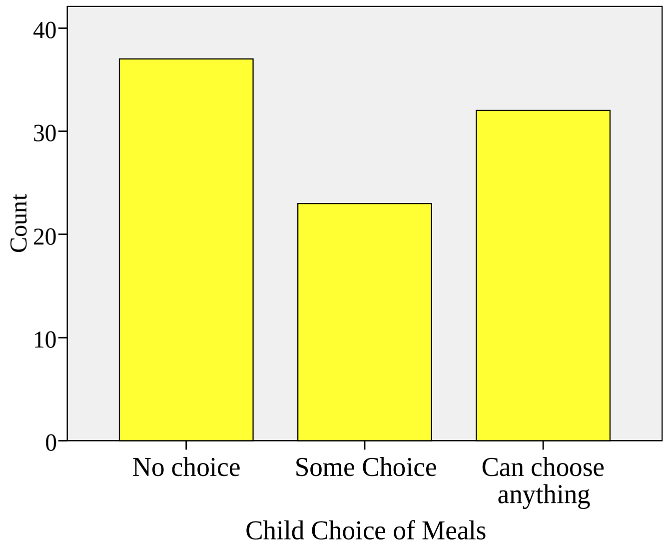
Others did not feel able to do so:

"When she wants something I [mum] never say no – I can't, she pulls a lovely face and I can't say no." (ID 43)

d) Children's Choice of Meals

For parents who wished to encourage consumption of certain foods and restrict others, various methods were described for doing so (further to those discussed above). A frequently mentioned method was limiting children's choice of meals (see Graph 7.4).

Graph 7.4: Children's Choice of Meals



Giving their children no choice of meals, so that they had to eat what they were given, enabled parents to regulate their children's food intake:

"I [mum] don't believe in asking children what they want to eat – I just give it to her then she'll eat it." (ID 42)

Some parents allowed their children to have some choice of what they ate for meals, for example giving them choices of different things, or suggesting something which their children could either agree or disagree with. Others allowed their children to have unlimited choice of meals. A main reason for allowing child choice was to prevent children from arguing and refusing to eat meals, which was easier and more convenient for parents:

"If she chooses what she wants she'll eat it." (ID 18)

"If you let kids choose then they'll eat it. If he wants it, he has it. As long as he eats it, I [grandmother, a main caregiver] don't mind."(ID 32)

Some parents felt that children have the right to choose their own meals[8]:

"You should ask children what they want to eat and give them that." (ID 38)

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[8] ***Desire for Child Independence and Autonomy***

Some parents valued child independence regarding diets and food intake. Value placed on child independence and autonomy was one reason for some parents allowing their children to eat what they wanted, when they wanted:

"Everyone has different tastes." (ID 34)

"She can eat what she wants. I [mum] treat her like an adult really." (ID 79)

These parents prioritised child autonomy and choice. Comparatively, parents who believed that they should monitor and regulate their children's food intake, including encouraging and restricting foods against their children's preference, valued "health" over child choice and independence for their diets.

Wanting children to eat independently (without parents feeding them) was also considered important by some parents, because they did not want to invest time each day in feeding their children:

"Don't want to get into habit of having to feed her every meal." (ID 62)

Child independence in eating was particularly desired by parents who felt pressured by time, including those with large families, and young babies. This parallels the desire for child independence in sleeping which was expressed by some parents, who did not want their children to rely on them for sleep each night (see Chapter 6).

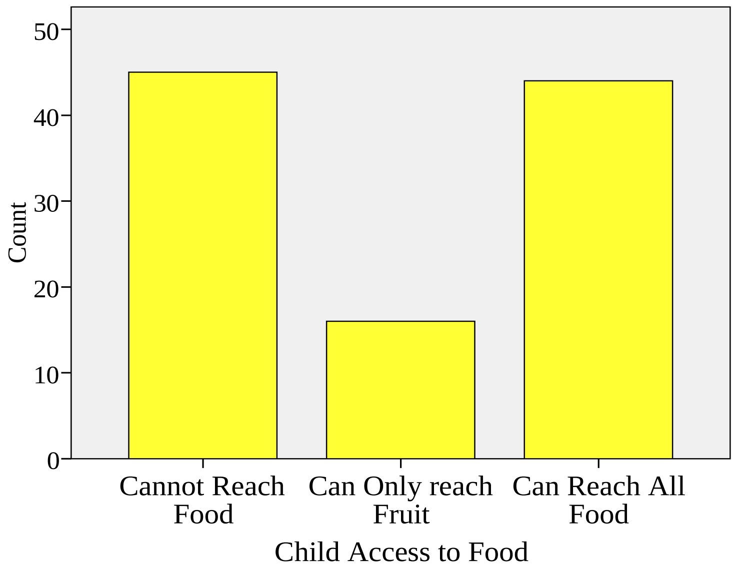
e) Children's Access to Food

Another method for regulating children's food intake was keeping foods inaccessible. Some parents simply kept restricted foods out of the house so that they could not be consumed. Others did not want their own diets to be affected by keeping foods out of the house, suggesting prioritisation of their own preferences over their children's diets:

"Other people in the house should be able to have them [biscuits and cakes]." (ID 27)

Where restricted foods were kept in the house, children's access to these foods varied (see Graph 7.5).

Graph 7.5: Children's Access to Food



Some parents kept food out of reach so that their children could not access it without parental permission. Another group of parents kept most food out of child reach, but left fruit accessible, because they did not want to restrict its consumption (because it was perceived as beneficial for child health). Both of these groups of parents restricted child access to what they perceived to be inappropriate or "unhealthy" foods.

In comparison, some parents described children being able to reach cupboards and fridges and to help themselves to food:

"He sneaks into the freezer and helps himself to ice cream, ice pops." (ID 104)

These parents considered restricted child access to food to be inappropriate:

"I [dad] don't believe in having food and things out of reach of children." (ID 51)
"When I [mum] was a child I always had to ask my parents if I wanted to eat anything. I always wanted my children to not have to ask." (ID 47)

Summary: Parents' Regulation of Children's Food Intake

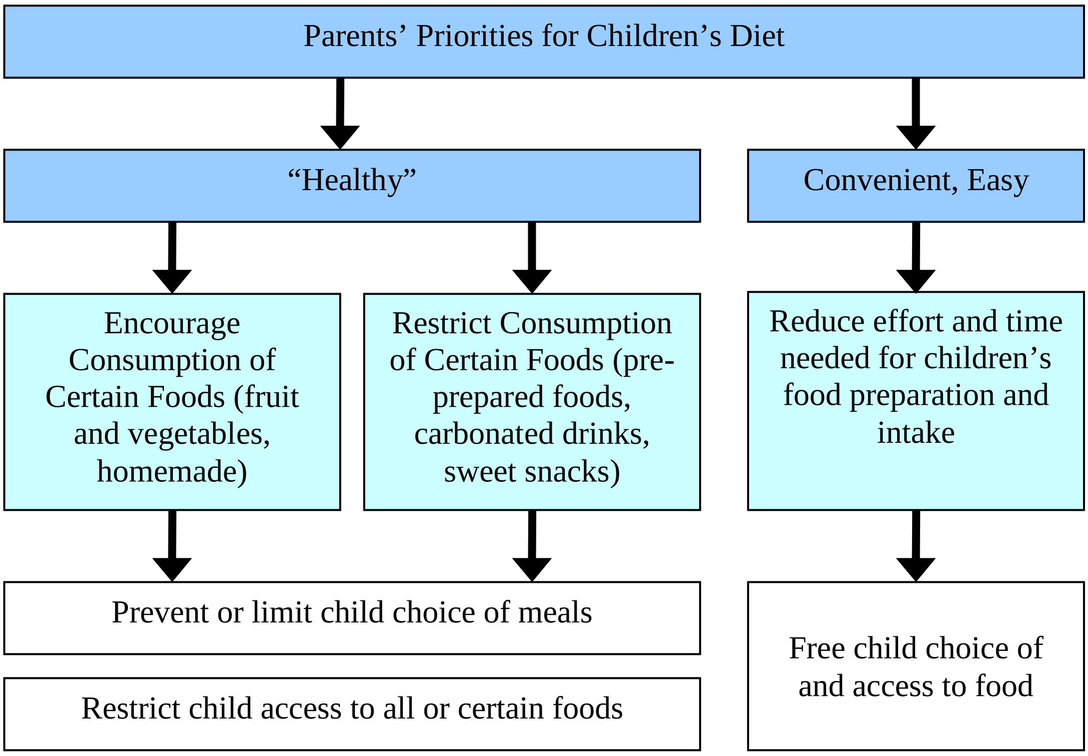
The descriptions above demonstrate variation in parents' priorities and aspirations for their children's diets, driving their food provision practices. Two main themes are evident:

1) Some parents prioritised children's consumption of "healthy" diets: they aimed to ensure adequate consumption of certain foods (mainly fruit and vegetables, homemade meals), and restriction of others (mainly pre-prepared foods, carbonated drinks and sweet snacks). In order to regulate their children's food intake to ensure that it was "healthy", parents employed methods such as preventing child choice of meals, and restricting access to food.

2) Other parents were less concerned about the types of foods consumed by their children, and considered convenience and effort to be more important aspects of their children's diets. In these households, parents employed methods to maximise ease and convenience: convenience and speed in preparation led to more frequent consumption of pre-prepared foods, whilst prevention of child resistance led to parents enabling their children to eat what they wanted, when they wanted.

These strategies are summarised in Figure 7.1. They are consistent with the correlations observed between servings of food groups (see Table 7.2). The dietary pattern of the former group of children can be summarised as frequent consumption of fruit and vegetables, infrequent consumption of pre-prepared foods and carbonated drinks, and moderate consumption of sweet items (which were used as rewards for consuming "healthy" foods). The dietary pattern of the latter group can be summarised as frequent consumption of pre-prepared foods and sweets, and less frequent consumption of fruit and vegetables.

Figure 7.1: Parents' Attitudes towards their Children's Diet, and Related Behaviours



Parents Regulation of Mealtimes

f) Structure of Daily Meals

Further to the types of foods consumed, mealtime practices represented variation in parents' attitudes towards children's diets. For some parents, mealtimes were seen as significant, structured occasions each day; for others, meals were less of a daily priority, and were more sporadic and unstructured.

The majority of parents provided 3 meals each day for their children. However, some did not, and for some children there were no distinct meals at all:

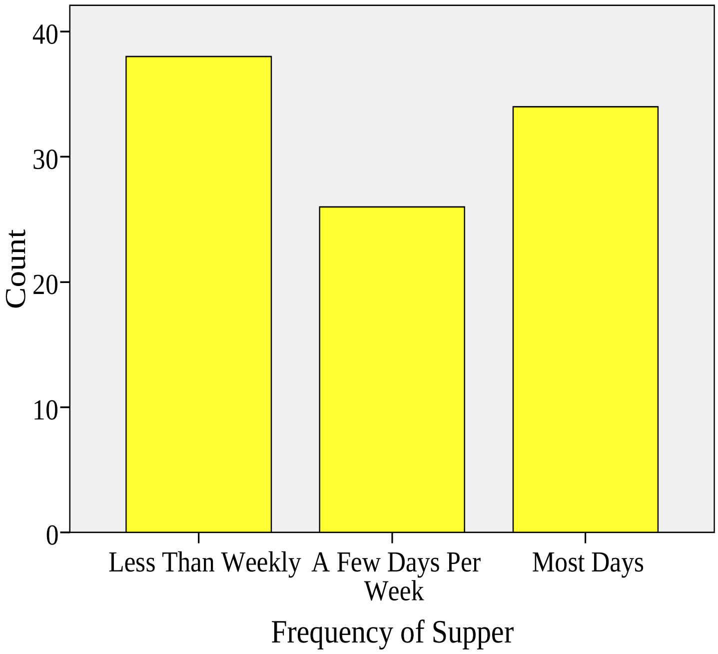
> *"She eats all through the afternoon, so she won't eat a meal at night."* (ID 9)
>
> *"He's more of a grazer."*(ID 57)
>
> *"She's more of a nibbler than eating proper meals."* (ID 54)

Examining the diary data revealed that throughout the diary period, 14 children did not have 3 distinct meals for each of the four days.

Regarding breakfast in particular, 73% of parents reported during interviews that their children ate breakfast every day. Other parents either gave their children breakfast every day but their children sometimes refused to eat it (23%), or did not provide their children with breakfast every day (4%).

Frequency of supper consumption (defined as food consumed after the main evening meal and before bedtime) was more varied between children compared to other meals (see Graph 7.6). Parents' attitudes ranged from trying to prevent their children from eating supper, to encouraging supper consumption to prevent children from going to bed hungry. The majority of parents were indifferent to whether their children ate supper or not, or reported that their children did not want supper anyway.

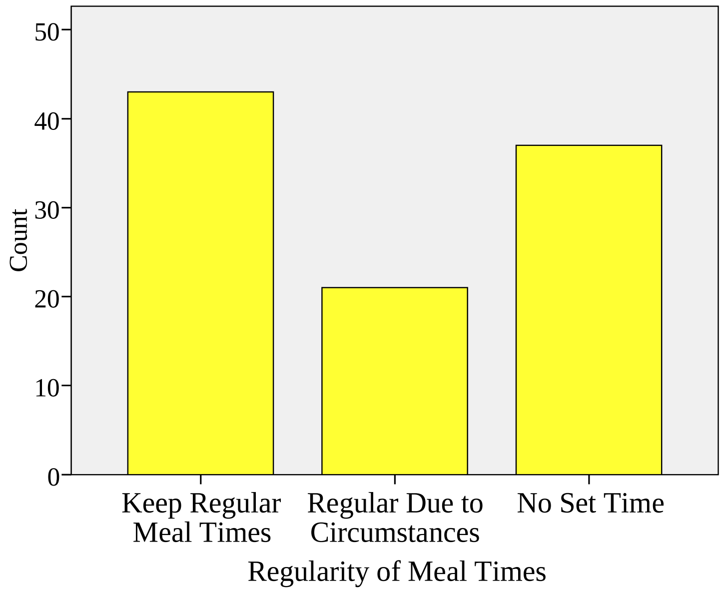
Graph 7.6: Frequency of Supper Consumption by the Children



g) Regularity of Meal Times

For children whose parents provided 3 meals each day, their regularity varied (see Graph 7.7).

Graph 7.7: Regularity of Meal Times



Some parents aimed to ensure regular meal times each day:

> *"I [mum] try to give him meals and snacks at the same time."* (ID 70)

Sometimes snacks were also kept at a regular time:

> *"Snacks are 'routined', as everything else is."* (ID 56)

Other children did not eat their meals at regular times: their parents reported meal times varying according to the activities of the day and their own preference for when to prepare and consume food. Sometimes when parents did not purposely intend meal times to be regular, they found them to be regular on most days because their children were hungry at the same time each day or because they came home from work and prepared meals at the same time. Both of these groups of parents did not consciously adhere to regular meal times. Maintaining regularity versus no regularity for meal times parallels differences in parents' attitudes towards regularity of bedtimes.

h) Children's Mealtime Locations

The location at which children ate meals further represents variation in parents' attitudes towards mealtimes. Usual meal locations for the children, as reported by parents, are shown in Table 7.6.

Table 7.6: Usual Meal Locations of the Children

Usual Meal Location		Frequency (%)
Kitchen or Dining Room Table		79 (75)
Living Room	At a Table	12 (11)
	On the Sofa	8 (8)
	On the Floor	4 (4)
Kitchen	Standing	1 (1)
	On a Worktop	1 (1)

Three quarters of the children usually ate their meals at a kitchen or dining room table. This was considered the "normal" and polite thing to do, and parents wanted their children to learn to do so:

"Children have to eat at the table, it's important to learn that. They have to stay 'til everyone's finished." (ID 28)

"They need to get used to sitting at a table for when they go out for meals." (ID 58)

For some parents, mealtimes were seen as important family occasions, and eating at a table was often synonymous with children and parents eating together. Some parents said that even if they were not eating themselves, they sat with their children at the table whilst they ate. Diary documentations revealed that 74% of children ate all of their meals with at least one other person, including parents, siblings, grandparents, friends, and other relatives. Twenty-six parents spontaneously mentioned that they try to ensure that their family eat meals together; of these 26, all but 2 ensured that these family meals occurred at a table:

"It's important for the family to sit down and eat together. We talk and interact with each other." (ID 91)

Further to structuring family time together, some parents encouraged their children to eat meals at a table and with other people because they felt that their children ate better:

"When they sit at the table they eat better, there's no distraction there." (ID 107)

"It's important for the little ones to see the older ones [older siblings] eating everything." (ID 91)

Some children did not eat their meals at a kitchen or dining room table; rather, they ate whilst sitting on the floor, wandering around, or in the living room. For some, this was because parents felt unable to ensure that their children sat at a table, or unable to spend time sitting at a table with their children each day:

"They won't stay there, they wander into the living room where we [parents] are."

(ID 2)

A main reason for children eating in the living room was so that they could watch TV, either to keep them entertained when eating alone, or so that their parents could watch TV if eating together[9].

Summary: Parents' Regulation of Children's Mealtimes

Parents' mealtime practices reflected their different priorities for children's diets, analogous to their behaviours regarding food types consumed:

1) Some parents prioritised structure and regulation: their children had meals at regular times, at a table, often with other people. This also encouraged children to eat better.

2) Other parents prioritised convenience and ease: mealtimes were at different times each day, to fit in when convenient; children were able to eat in locations other than at a table, and often alone (including on the sofa watching TV), which reduced effort and time required by parents, and enabled them to carry on with their own activities.

[9] ***TV Viewing Whilst Eating***

Parents' attitudes towards children watching TV whilst eating varied. Some parents found that children would not eat as well whilst watching TV:

"I [mum] don't let him watch TV when eating or he wouldn't eat." (ID 44)

"She used to watch TV while eating breakfast but I [mum] stopped that now, she was getting distracted and not eating properly." (ID 55)

Other parents used the TV as an aid to make children eat:

"*We've [parents] recently put him in front of the TV to eat his meals 'cause he'll be distracted and eat it."* (ID 88)

The use of TVs to entertain children was also a method parents used to allow them to cook meals, and a method to allow parents to carry on with their own tasks whilst their children ate:

"I [mum] use the TV to entertain them while I cook." (ID 48)

"*I [mum] let them eat breakfast in the living room watching TV, it's easier so I can get on with things."* (ID 58)

Parenting Strategies for Children's Diets

For the topics described above (regulation of foods consumed, and mealtime practices), parents' attitudes and behaviours were driven by their priorities for their children's diets. These can be broadly distinguished into 2 strategies:

- Strategy A: Some parents valued "healthy", consistent and regulated diets for their children. Accordingly, they encouraged consumption of certain foods, and restricted consumption of others. Preventing child choice of meals and access to food enabled parents to regulate their children's food intake. Regarding mealtimes, eating meals at a table and with other people assisted in children eating well. Regulating mealtimes by having their children eat at a table, with other people, and at regular times each day, gave mealtimes priority within the day, and was another aspect to maintaining routine, consistency and structure in children's diets.

- Strategy B: Some parents valued convenience and ease for their children's diets. Accordingly, children were able to eat what they wanted, when they wanted, where they wanted. This was more convenient, and minimised child resistance and parental effort. Allowing children to have free access to, and choice of, foods also reflected some parents' desires for child independent choice. Children whose food intake and mealtimes were unregulated and unstructured by their parents were self-governing regarding their diets.

Parents' attitudes and behaviours regarding children's diets and mealtimes were categorised according to these strategies (see Table 7.7). Those behaviours listed under Strategy A reflect parents' use of regulation, consistency and limit-setting for children's food intake and mealtimes, in order to prioritise their childrens' healthy eating. As such, they are analogous to the routine-led behaviours for sleep (see Chapter 6); hence they are termed routine-led for diet. Those behaviours listed under Strategy B reflect child choice and self-governance of food intake and mealtimes, and absence of parental regulation, consistency and limit-setting, in order to prioritise convenience and ease for parents. As such, they are analogous to the routine-free parenting behaviours for children's sleep (Chapter 6); hence they are termed routine-free for diet.

Table 7.7: Parenting Behaviours Reflecting Different Strategies for Children's Diet

Topic	Parenting Behaviours for Child Diet: Parenting Strategy A: "Routine-Led"	Parenting Behaviours for Child Diet: Parenting Strategy B: "Routine-Free"
Restriction of Foods	Parent restricts or bans certain foods totally (n=63)	Parent does not restrict any foods (n=45)
Children's Choice of Meals	Child has no choice for meals (n=37)	Child has some or free choice for meals (n=55)
Children's Access to Food	Child has no access to food, or access to fruit only (n=62)	Child has free access to food (n=44)
Regularity of Mealtimes	Parent tries to maintain regular meal times (n=43)	Parent does not intend to maintain regular meal times (n=58)
Children's Usual Mealtime Location	Child usually eats meals at a kitchen or dining room table (n=79)	Child usually eats meals at a location other than a kitchen or dining room table (n=26)

Associations amongst the parenting behaviours for each strategy regarding children's diets are shown in Table 7.8.

Table 7.8: Associations of Parenting Behaviours for Children's Diets

Chi-Square, X^2	*Usual Mealtime Location*	*Regularity of Meal Times*	*Children's Access to Food*	*Children's Choice of Meals*
Restriction of Foods (some versus no foods restricted)	11.43 ***	6.16 *	32.62 ***	11.68 ***
Children's Choice of Meals (no versus Some/free choice)	5.77 *	0.02	8.60 **	
Children's Access to Food (no/fruit only versus free access)	10.13 **	10.33 **		
Regularity of Meal Times (intend versus do not intend meals to be regular times)	3.94			

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

See Appendix K: Frequency Tables for Associations of Parenting Behaviours for Children's Diets

Routine-led parenting behaviours for diet were significantly correlated together, whilst routine-free parenting behaviours were significantly correlated together. This clustering of routine-led and of routine-free behaviours supports the idea that these represent two distinct underlying parenting strategies: one which prioritises regulation of children's food intake and mealtimes; and one which prioritises convenience and ease, with absence of regulation.

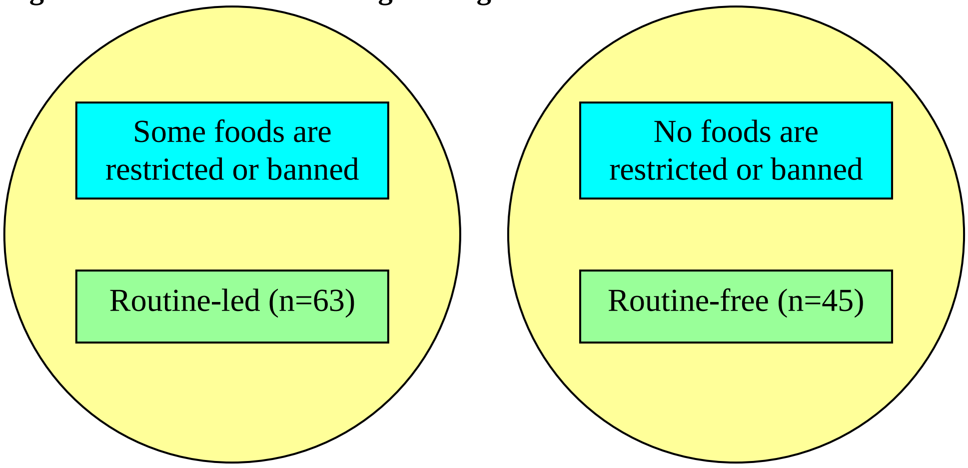
The only non-significant correlations were of regularity of meal times with both children's choice of meals and usual mealtime location. Perhaps this indicates that regularity of mealtimes is not as strong an indicator of parents' regulation, routines and limit-setting for diet and mealtimes as it is for sleep: whilst regularity of bedtimes was strongly associated with all components of routine-led parenting for sleep, regularity of mealtimes was not associated with all components of routine-led parenting for diet.

Since parenting behaviours in each strategy are significantly correlated together, one will be used to represent parenting strategy for diet in further analyses. Restriction of foods represents parents' intentions regarding regulation of children's diets, and is significantly correlated to each of the other behaviours. Parents who restricted some foods will be considered routine-led, and those who did not restrict any foods will be considered routine-free for children's diets.

Summary: Parents' Attitudes and Behaviours Regarding Children's Diets

General variation in parents' attitudes and practices regarding mealtimes and diet was identified: routine-led parents promoted "healthy" diets by encouraging consumption of certain foods and restricting others; they prioritised consistency and regulation for food intake and mealtimes. Routine-free parents did not regulate their children's food intake or mealtimes; children were able to eat what they wanted, when they wanted, and mealtimes were irregular and unstructured. There was clustering of routine-led parenting behaviours and of routine-free parenting behaviours for diet. Restriction of foods is representative of routine-led (some foods restricted or banned) versus routine-free (no foods restricted) parenting strategies for children's diets, as shown in Figure 7.2.

Figure 7.2: Different Parenting Strategies for Children's Diets



Examination of Parenting Strategies for Children's Diets

This section will explore the parenting strategies for children's diets identified above. Associations of parenting strategy for diet with children's food intake (and consequential risk for obesity) will be investigated, and variation in parenting strategies with SES and ethnicity will be assessed.

Parenting Strategies for Diet and Children's Food Intake

Food intake was compared between children whose parents were routine-led versus routine-free for diet (see Table 7.9).

Table 7.9: Comparison of Child Sleep with Parenting Strategy for Diet

Independent t-test, Mann-Whitney U, Chi-Square	Parenting Strategy Regarding Child Diet		t, U or X^2 value	p value
	Routine-Led (n=63)	Routine-Free (n=45)		
Daily Servings of Fruit & Vegetables	1.88 (0-4.50)	1.00 (0-3.00)	U=564	.002
Daily Servings of Pre-Prepared Foods	1.00 (0-3.00)	1.50 (.50-2.50)	U=446	<.001
Daily Servings of Sweets	1.28 (.72)	1.24 (.77)	T=.25	.806
Consumed Carbonated Drinks (%)	26	38	X^2=2.82	.120

Children of routine-led parents consumed more fruit and vegetables per day, and fewer pre-prepared foods, compared to children of routine-free parents. Consumption of carbonated drinks was not associated with parenting strategy: this may be due to the large number of parents who did not report any drinks in the diaries, and the absence of fruit juices and other sugary drinks from analyses (see above). Parenting strategy was also not associated with daily servings of sweet foods: perhaps this is because routine-led parents often allowed sweet treats (see above), leading to provision of sweets being less varied between routine-led and routine-free parents compared to other food groups. Alternatively, the lack of significance for servings of sweets may be due to parents not knowing when and what sweets their children ate, and not reporting these accurately. Routine-free parents described their children helping themselves to food without their parents' knowledge, particularly snack foods and sweets; perhaps sweet snack foods were therefore less accurately documented by parents. In comparison, pre-prepared foods were served mainly at mealtimes (for example frozen foods and takeaways were consumed for meals), which parents were aware of, and able to document more accurately. Since foods in the fruit and vegetable category were consumed as snacks as well as meals, it is possible that routine-free parents whose children helped themselves to snacks were also not able to document this group accurately; however, some routine-led parents also described allowing their children to help themselves to fruit. Qualitative data suggested that routine-led parents encouraged children to consume fruit and vegetables more so than routine-free parents, which supports the findings here, that children of routine-free parents were more likely to eat less healthful foods, and consumed fewer fruit and vegetables.

Since fruit and vegetables are obesity-protective, and pre-prepared foods are obesity-promoting (see Chapter 3), these results suggest that children whose parents were routine-free for diet had food intake patterns which put them at greater risk for becoming obese compared to children whose parents were routine-led.

There is inconsistent evidence in the literature regarding a positive or negative influence of parental control on children's diets and weight (see Chapter 3). The results here support a correlation of parental control and regulation with more healthful (less obesity-promoting) children's food intake. This is in keeping with Wardle et al.'s (2002) documentation of preschool children at risk for becoming obese having parents who showed less control of their diet in comparison to normal-weight children.

In Brown et al.'s (2008) study, which similarly found parental control of diet to be correlated with greater intake of fruit and vegetables and reduced intake of "unhealthy" foods in preschool children, the type of control used by parents was important. Covert control had positive associations and overt control had negative associations with children's diets. Routine-led behaviours in the present study were analogous to covert control: for example, routine-led parents prepared meals containing the foods they deemed appropriate, without allowing child choice, which did not draw attention to the presence or absence of certain foods. Similarly, some routine-led parents restricted children's access to certain foods by keeping them out of the house or out of reach, in accordance with Brown et al.'s measure of covert control (they asked parents "Do you avoid having snack foods/ unhealthy foods in the house?"). The results here lend support to a positive association of particularly covert control with more healthful food intake patterns in children.

Pressure to eat is a form of overt control, and has been more consistently negatively correlated with children's food intake and weight (see Chapter 3). Parents in this sample did not report pressure to eat; even routine-led parents, who regulated their children's food intake, were reluctant to encourage children to keep eating once they were full (see above). This is again consistent with routine-led behaviours in this study being more covert than overt.

Regarding mealtimes in particular, the results here support previous findings that eating meals as a family is associated with more healthful dietary intake patterns and reduced risk of overweight (see Chapter 3). Since eating meals at a kitchen or dining room table, and as a family, were commonly analogous with parents valuing family interactions at mealtimes, whilst eating in the living room was commonly described so that children could watch the TV whilst eating, these results support previous findings that children's diets are influenced by the people who they eat with, interactions with those people, and whether the TV is on during meals (see Chapter 3).

SES and Parenting Strategy for Diet

Frequencies of parenting strategies for children's diets in deprived and affluent groups were compared (see Table 7.10).

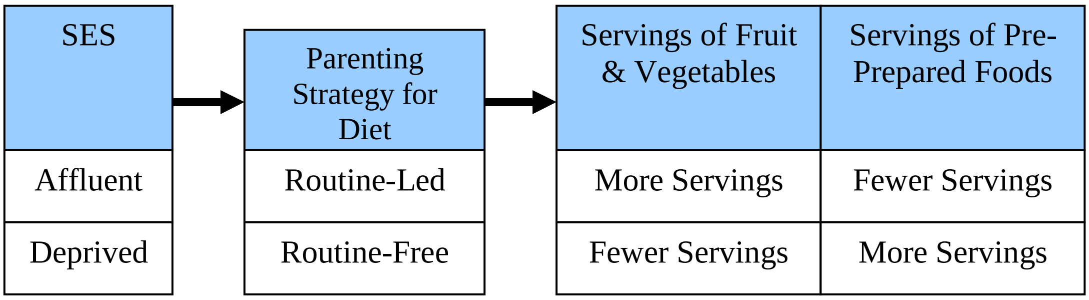
Table 7.10: Frequencies of Parenting Strategies for Diet in each SES Group

Parenting Strategy for Diet	SES		X^2	p value
	Affluent	Deprived		
Routine-Led (n)	39	24		
Routine-Free (n)	10	35	16.68	<.001

Parents who were routine-led for children's diet were significantly more likely to live in affluent areas, whilst routine-free parents were more likely to live in deprived areas. This is consistent with routine-led and routine-free parenting for sleep being more frequent in affluent and deprived areas respectively (see Chapter 6).

Again, although causality cannot be determined, it is likely that SES influences parenting strategy; since SES and parenting strategy for diet are significantly associated, and both are correlated with daily servings of fruit and vegetables and pre-prepared foods (see Tables 7.4 and 7.9), there may be mediation between the variables, as shown in Figure 7.3.

Figure 7.3: Possible Mediation of SES-Food Intake Associations by Parenting Strategy



Ethnicity and Parenting Strategy for Diet

Frequencies of parenting strategies for children's diets in each ethnic group were examined (see Table 7.11).

Table 7.11: Frequencies of Parenting Strategies for Diet with Ethnicity

Parenting Strategy for Child Diet	Ethnicity		X^2	p value
	White British	BME		
Routine-Led (n)	58	5		
Routine-Free (n)	37	8	2.4	.142

Although more white British parents were routine-led compared to routine-free for children's diets, and more BME parents were routine-free compared to routine-led, there was no significant variation in parenting strategy with ethnicity; this may be due to the small number of BME compared to white British families in the sample.

Similarly to sleep, further investigation into ethnic variation in parenting behaviours is needed, in order to examine the contribution of parenting to children's food intake and ethnic variation in children's diets.

Summary: Examination of Parenting Strategies for Children's Diets

Children whose parents were routine-led for diet received more fruit and vegetables and fewer pre-prepared foods per day compared to those whose parents were routine-free, suggesting an association of routine-free parenting with a relatively more obesity-promoting diet. This supports a positive association of parental control and regulation (particularly covert) with more "healthful" children's diets. Similarly to sleep, routine-led parenting for diet was significantly more likely for parents in affluent areas, whilst routine-free parenting was more prevalent in deprived areas.

Section Summary: Diet

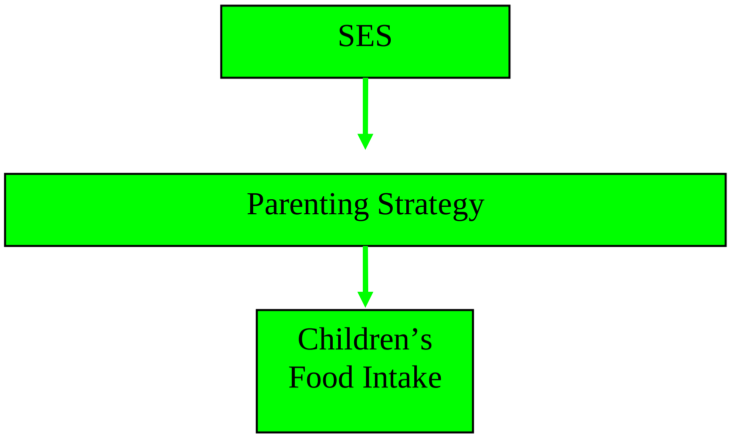
This section of the chapter examined children's food intake patterns, parents' attitudes and practices regarding children's diets and mealtimes, and associations of parenting with children's food intake. Servings of obesity-promoting foods were correlated together (with the exception of sweets). Distinct parenting strategies for children's diets were identified, which were associated with children's food intake: routine-led parenting was associated with more "healthful" food intake, whilst routine-free parenting was associated with more obesity-promoting food intake. Routine-led parenting for children's diets was more frequent in affluent areas, whilst routine-free parenting was more frequent in deprived areas, suggesting a potential mediating role of parenting in associations of SES with children's food intake.

The exploratory and cross-sectional design of this study means that associations and direction of causality cannot be confirmed. Based on the results presented in this section of the chapter, in addition to the literature reviewed in Chapters 2 and 3, I have formulated Model B, as shown in Figure 7.4. This model will be expanded on and discussed in the remainder of this chapter and the following chapters.

Figure 7.4: Model B

Children's food intake is influenced by parenting strategy (routine-free parenting is associated with obesity-promoting children's food intake compared to routine-led parenting).

Parenting strategy mediates the relationship between SES and children's food intake (higher SES parents are more likely to be routine-led, and lower SES parents are more likely to be routine-free; children in lower SES groups have a relatively obesity-promoting diet compared to those in higher SES groups).



Children's Activity Patterns

The second section of this chapter will explore physical and sedentary activities in the children, and parents' attitudes and practices regarding their children's activities. Specifically, this section will a) describe the physical and sedentary activity patterns of the children, b) examine associations of children's activity with ethnicity, SES and body composition, c) discuss parents' attitudes and behaviours towards their children's activity patterns, and d) explore associations between parents' behaviours and children's activities.

Time Spent in Physical Activity

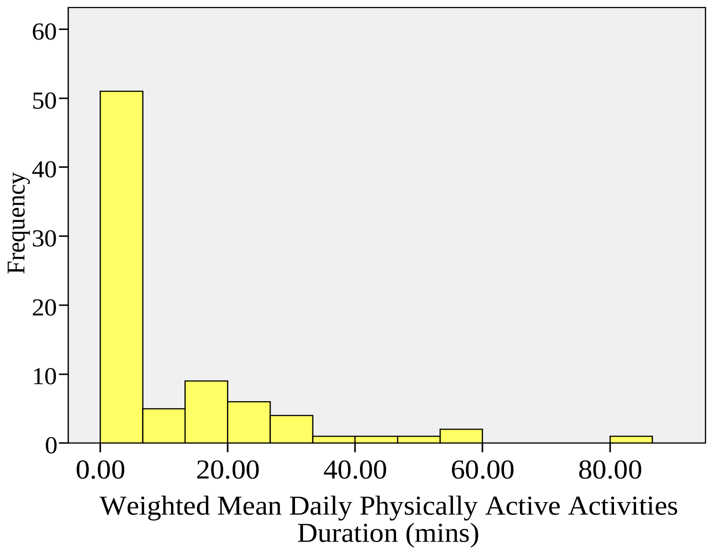
Weighted mean daily durations (as documented in the diaries) for physical play, walking, other activities which were considered to be physically active (such as dancing, swimming, bike, park, football), and for the total of all of these physical activities, are shown in Table 7.12.

Table 7.12: Diary Physical Activity Duration Data: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Weighted Mean Daily Physical Play (mins)	81	3	330	128	72	125
Weighted Mean Daily Walking (mins)	81	0	174	36	30	31
Weighted Mean Daily Physical Activities (mins)	81	0	86	10	16	0
Weighted Mean Total Daily Physical Activity (mins)	81	26	356	175	76	179

The number and types of entries for activities differed greatly between parents. Some parents entered numerous activities per day, including activities which were short in duration. Others entered zero or few activities per day, often only entering activities which were long in duration. Some entered only activities which were listed in the diaries (physical play and walking): more than half of the children (58%) had no record of time spent in physical activities other than physical play and walking (see Graph 7.8). This suggests that there may have been inconsistency in documenting of activities by parents.

Graph 7.8: Distribution of Weighted Mean Daily Duration of Physical Activities



Descriptions of activities and their designation as ‘physical’ were subjective and varied between parents. Despite being given the same instructions regarding completion of the diary, some parents considered time spent playing with toys and doing jigsaws to be physical play (they ticked physical play and then described these activities), whilst others only reported time spent in the park or playing sport as physical play (all of their entries listed under physical play were outdoor activities such as playing in the park, playing football, riding bikes). Other parents reported physical play and TV viewing as co-occurring (they ticked both boxes for the same time period), indicating that physical play in these situations was more static and likely to be less vigorous compared to playing football and riding bikes.

Since variation in time spent in physical activities is likely to have resulted not only from actual variation in physical activity levels between children, but also from inconsistent reporting between parents, differences in perception of what physical play is, and differences in consideration of what activities should be documented, confidence in the accuracy of physical activity duration as a marker of child physical activity level in this sample is low. Assessment of daily physical activity duration was therefore not considered in further analyses.

Time Spent in Sedentary Activity

TV viewing and use of computers are less ambiguous than are physical activities; hence their documentation in the diaries is likely to be more consistent between parents. Most parents reported during interviews that their children were not very interested in computers and computer games, and did not use them frequently or for long, if at all. When they were used, the types of computer games that parents most commonly described children playing with were hand-held electronics such as Nintendo DS. In keeping with parents’ descriptions, the majority of children (75%) were not documented to have played on a computer at all during the diary period. Across the whole sample, the median value for daily duration of computer use was 0 minutes, and the mean value was 7 (±17) minutes per day. Since computer playing was an infrequent activity for children in this sample, it was not analysed further.

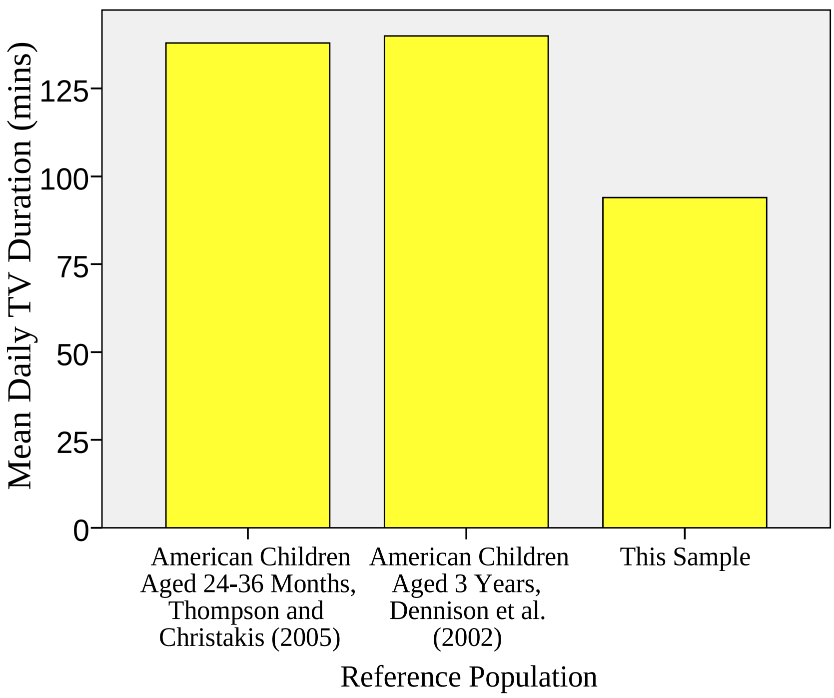
TV viewing was much more frequent than computer use, with all children documented as watching at least some TV during the diary period. As discussed above, TV viewing entries in the diaries were sometimes reported as co-occurring with other activities: it was not possible to distinguish between periods of exclusive TV viewing and TV viewing in combination with other activities. Descriptive data for duration of daily TV viewing and latest timing of TV viewing across all days are shown in Table 7.13.

Table 7.13: Daily TV Viewing Duration & Latest TV Viewing Time: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Weighted Mean TV Viewing Duration (mins)	85	1	323	94	64	80
Latest TV Viewing Time Across all Days (hh:mm)	80	08:25	21:45	18:41	02:17	19:00

The American Academy of Pediatrics (2001) recommends a daily limit of 1 to 2 hours of TV viewing for children older than 2 years of age: 25% of children in this sample watched an average of more than 2 hours of TV per day. However, mean daily duration of TV viewing was less than that reported by parents in two American samples of preschool children (see Graph 7.9).

Graph 7.9: Daily TV Viewing Duration Compared to Reference Preschool Populations



There was a significant positive correlation between latest TV viewing time and weighted mean TV viewing duration (see Table 7.14), indicating that children who watched TV until later in the evening watched more TV overall.

Table 7.14: Association between Latest TV Viewing Time and Daily TV Viewing Duration

Spearman's Correlation, r_s	Latest TV Viewing Time (n=80)
Weighted Mean TV Viewing Duration	.29 **

* p≤ .05   ** p≤ .01   *** p≤ .001

Forty-three percent of children in this sample had a TV in their bedroom. This is greater than the proportion reported for two samples of American preschool children, of 40% and 30% respectively (Dennison et al., 2002; Mindell et al., 2009a).

Duration of TV viewing and latest time of TV viewing were compared between children who did and did not have a TV in their bedroom (see Table 7.15): there were no significant differences. This suggests that duration and timing of TV viewed were not associated with the presence of a TV in the bedroom.

Table 7.15: Variation in TV Viewing Duration and Latest Time of TV Viewing with Having a TV in the Bedroom

	TV in the Bedroom		U	
Mann-Whitney U	Yes (n=46)	No (n=62)	statistic	p value
Weighted Mean Daily TV Viewing Duration (mins) (median (range))	85 (16-323)	71 (1-285)	672	.176
Latest TV Viewing Time (hh:mm) (median (range))	19:07 (12:45-21:45)	19:00 (8:25-21:30)	673	.530

It is possible that parents did not monitor TV viewing in their children's bedrooms, thereby underestimating TV viewing duration and the time at which the TV was switched off; however, during interviews some parents described returning to their children's bedroom to switch the TV off themselves, so they would know the time at which children stopped watching TV.

Summary: Children's Activity Patterns

Diary data regarding physical activities will not be used in further analyses due to concerns regarding inconsistent reporting between parents, differences in perception of what constitutes physical play, and differences in the types of activities documented by parents. Regarding sedentary activities, computer use was low in this population, whilst a quarter of children watched an average of more than 2 hours of TV per day. Children who stopped watching TV later in the evening watched more TV overall, but they were not more likely to have a TV in their bedroom.

Children's Activity: Associations with Ethnicity, SES, and Body Composition

This section of the chapter will examine potential associations of children's sedentary activity patterns (TV viewing) with ethnicity and SES, and with body composition.

Ethnicity and Children's TV Viewing

Comparisons in TV viewing were made between white British and BME children (see Table 7.16). There were no significant differences, which is contrary to previous findings of variation in TV viewing with ethnicity (see Chapter 3). However, the proportion of BME children is low, meaning that caution is needed when considering ethnic variation in this sample.

Table 7.16: Comparisons in Children's TV Viewing with Ethnicity

Mann Whitney U, chi-square X^2	White British (n=95)	BME (n=14)	Statistic	p value
Weighted Mean TV Viewing Duration (mins) (median (range))	81 (9-323)	65 (1-166)	U=195	.498
Latest TV Viewing Time (hh:mm) (median (range))	19:00 (8:25-21:45)	19:20 (15:00-21:30)	U=200	.687
TV in the Bedroom (%)	44	31	X^2=.85	.551

SES and Children's TV Viewing

Comparisons in TV viewing were made between children in deprived and affluent SES groups (see Table 7.17).

Table 7.17: Comparisons in Children's TV Viewing between SES Groups

Mann Whitney U, chi-square X^2	Deprived (n=60)	Affluent (n=49)	Statistic	p value
Weighted Mean TV Viewing Duration (mins) (median (range))	94 (1-323)	71 (9-236)	U=626	.022
Latest TV Viewing Time (hh:mm) (median (range))	19:12 (14:30-21:45)	19:00 (8:25-21:30)	U=628	.096
TV in the Bedroom (%)	64%	16%	X^2=25.31	<.001

Children living in deprived areas were more likely to have a TV in their bedroom, and watched significantly more TV per day compared to children in affluent areas. This is consistent with documentation of increased TV viewing in children in lower socioeconomic groups (see Chapter 3).

Body Composition and Children's TV Viewing

Associations of TV viewing with body composition were examined (see Table 7.18).

Table 7.18: Associations of Children's Anthropometric SD Scores with TV Viewing

Spearman's Correlations r_s, *Independent t-test t*	BMI SD Score (n=101)	Waist Circumference SD Score (n=100)	Triceps Skinfold SD Score (n=98)	Subscapular Skinfold SD Score (n=96)
Daily TV Viewing Duration	r_s= .04	r_s= .09	r_s= -.01	r_s= .18
Latest TV Viewing Time	r_s= .05	r_s= .09	r_s= -.14	r_s< .01
TV in the Bedroom (Yes versus No)	t= .45	t= .52	t= .88	t= -.65

There were no significant associations of TV viewing with body composition. This is contrary to previous findings of TV viewing and the presence of a TV in the bedroom being positively associated with obesity (see Chapter 3).

However, TV viewing in young children has more commonly been correlated with risk of obesity in later life: duration of TV viewing in preschoolers was positively correlated with obesity at age 7 years (Reilly et al., 2005), and with increase in body fat (Proctor et al., 2003) and accelerated BMI growth (Danner, 2008) over the following years. Hence, similarly to dietary intake, TV viewing patterns, although not associated with current body composition and weight status, are likely to be associated with weight gain and future risk of obesity.

Summary: Children's Activity: Associations with Ethnicity, SES, and Body Composition

Children living in deprived areas watched more TV per day and more frequently had a TV in their bedroom compared to children in affluent areas. There were no associations of TV viewing habits with body composition, but watching more TV and having a TV in the bedroom may impact on future risk of becoming obese.

Parents' Attitudes and Behaviours Regarding Children's Activities

This section will explore parents' attitudes and practices regarding children's activities. Key topics will be discussed (including common activities, weekly schedules, and TV viewing habits), themes arising from the interviews will be identified, and parenting strategies regarding children's activities will be investigated.

a) Scheduling of Activities

During interviews, parents discussed activities which occur during a typical day and a typical week (other than time that their children spend at nursery). Some parents described a regular daily or weekly schedule of activities. This frequently included children attending weekly scheduled events such as football training or a gym. Some parents dedicated an amount of time each week to their children's activities, but these were not consistent each week, for example they took their children to a park or to a museum of their choice at least weekly. Contrastingly, for other households there was no regular pattern of events. Each day and week were not scheduled and there was no mention of time dedicated to children's activities.

b) Encouragement of Activities

Some parents encouraged their children to undertake certain activities over others. For example, 17 parents mentioned that they encourage their children to read or to use flash cards (to aid their education and development), and 8 parents mentioned that they encourage their children to play outside (to be active and fit):

"My children exercise whatever the weather, running around the park." (ID 96)

These parents were keen to promote activities which they considered to be good for their children's development and health. Parents often took an active role in activities which they wished to promote, for example reading with their children, or taking them to the park regularly to play outside.

Further to activities which were perceived to be good for their children's health and development, some parents reported wanting to do activities together with their children to enjoy time together. Spending time as a family was particularly important for some, and this usually occurred on weekends when there were no school or work schedules. Nineteen parents mentioned the importance of spending weekly time together as a family. Again, some parents scheduled weekly events to ensure this time with their children, for example mother-toddler sessions; and others described how they make special time at least weekly to spend together with their family:

"I [mum] get my jobs done while he's at nursery so when he's home we can do things around him." (ID 52)

"We [parents] like to do things with the children on weekends. Some parents don't want to, so why did they have children?" (ID 53)

For some parents there was a compromise, whereby children had to fit in with parents' jobs and schedules some of the time, but also had some time in the week which would be devoted to them:

"Children need to know that the house needs to run, to do practical things as well as fun things." (ID 48)

Contrastingly, other parents did not describe any encouragement of particular activities for their children; rather, children were able to do what they wanted. This was either because parents did not feel able to influence their children's activities, or because they did not wish to do so:

"You should give kids a choice rather than make him do things." (ID 40)

Some parents felt that it was easier to allow children to determine their own activities, since it did not require as much parental effort:

"I'm [mum] probably meant to encourage them to read, and to read books to them in the evening, but I don't." (ID 24)

"We [parents] give her freedom over what she wants to do, who we go visit… then she's better behaved." (ID 43)

Some parents specifically did not want to prioritise their children's activities over their own:

"I [mum] need to do things so I can't be with her all the time… she plays in her room." (ID 6)

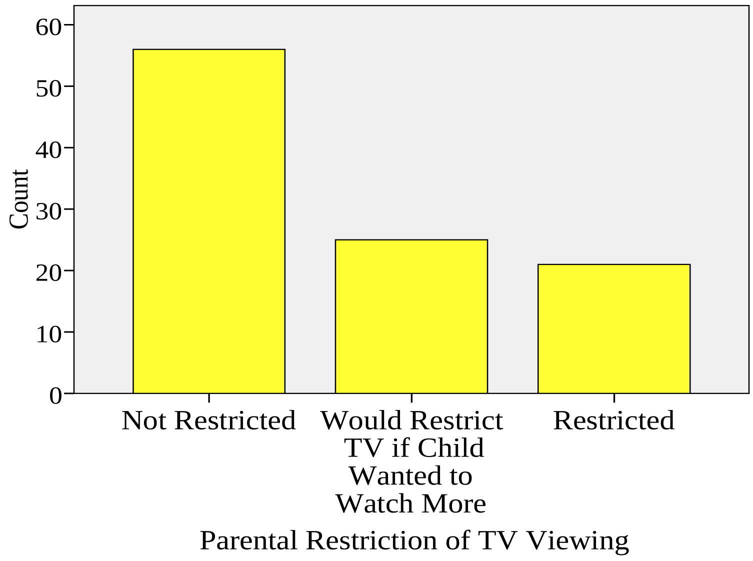
"Children have to fit in with parents." (ID 107)

Some parents balanced time with their children and time for themselves throughout the day and week, and requiring time away from their children does not necessarily mean that parents were overlooking their children's needs. However, at one extreme, six parents spontaneously said during interviews that they try to have their children cared for by other relatives for long periods of time during the week (for example for a whole weekend) so that they can have time to themselves to carry out their preferred activities. This degree of requiring time without their children indicates prioritisation of parental needs and desires over children's activities and time with their children.

c) Restriction of TV Viewing

Further to encouraging certain activities, some parents restricted or limited activities for their children, mainly TV viewing. Some parents restricted TV viewing to a certain amount or a certain period per day. Others said that their children were not interested in watching TV so they did not need to restrict it, but that if they did want to watch more TV then it would be restricted. These two sets of responses demonstrate similar intention to regulate and limit TV viewing in children, compared to parents who did not monitor or restrict TV viewing (see Graph 7.10). (Note that this concerns restriction of amount of TV viewed, rather than content.)

Graph 7.10: Parental Restriction of the Child's Amount of TV Viewing



Reasons for restricting TV viewing duration included parents preferring their children to do other things, particularly things which were more physically demanding and more socially stimulating or engaging (see Figure 7.5). Some parents discussed strategies to prevent their children from watching too much TV, for example creating other things for them to do; others simply did not allow the TV to be on for longer than the restricted time period. Reasons for not restricting TV included parents not considering excessive TV viewing to be bad for their children; and the benefits for parents of children being entertained by the TV (see Figure 7.5).

Figure 7.5: Parents' Reasons Restriction or No Restriction of Children's TV Viewing

Parents' Reasons for Restricting or Not Restricting Children's TV Viewing

Reasons for restricting TV viewing	*Reasons for not restricting TV viewing*	
	Parents Indifferent to Child's TV Viewing	Parents Like Child to Watch TV
"I'd [mum] rather they were doing other things." (ID 58) *"I [mum] don't like them sitting not playing or talking."* (ID 56)	*"She can watch as much TV as she wants, she's not disturbing anyone, she's not causing any trouble."* (ID 28) *"TV isn't limited because it's educational."* (ID 85)	*"I [mum] use the TV to distract, entertain the children while I do my jobs."* (ID 63) *"We [parents] use the telly to keep her focussed – she'll watch that and we can get on."* (ID 62)

Similarly to lack of encouragement of particular activities, lack of TV viewing restriction reflected parents' prioritisation of ease and convenience, since it allowed parents to continue with their own activities, and:

"There's no point making her do something she doesn't want to do or switch the TV off when she doesn't want to, it's not worth the hassle." (ID 54)

Lack of restriction of TV viewing for some parents demonstrated prioritisation of their own activities and desires over their children's:

"I [mum] won't make him do anything he doesn't want to. We [parents] only stop him watching TV or playing computer games when we're bored of playing on the computer with him, or we want to watch our programmes on TV, then he can watch the TV in his room." (ID 47)

Some parallel barriers to implementing a limit on their children's TV viewing have previously been reported by parents of American school children (aged 6-13 years); these included parents' need to use the TV as a safe and affordable distraction, adherence to parents' own TV viewing habits, and parents' belief that children should spend their leisure time as they wish (Jordan et al., 2006).

Parenting Strategies for Children's Activities

For the topics described above (scheduling of activities, encouragement of certain activities and restriction of TV viewing), parents' attitudes and practices were driven by differing strategies and priorities for children's activities:

- Strategy A: Some parents promoted activities which they believed to be good for their children's health and development (physical activity, reading), and restricted those which were not (TV viewing). These parents often encouraged the undertaking of activities together as a family, which demonstrates prioritisation of social time together as a family. Often these parents scheduled weekly activities accordingly for them and their children, or provided time in the week to do activities with, and for, their children.

- Strategy B: Some parents did not encourage certain activities for their children, or restrict TV viewing. This was easier and more convenient because it enabled parents to continue with their own activities and to prioritise their own schedules; and because it prevented resistance by children. Daily and weekly activities for these children were unstructured and unregulated, and children were independent and self-governing regarding their activities.

Parents' attitudes and behaviours regarding children's activities were categorised according to these strategies (see Table 7.19). Those behaviours in Strategy A reflect parents' use of regulation and limit-setting for their children's activities, and are therefore analogous to the routine-led behaviours for children's sleep and diet (Chapter 6, and above): hence they are termed routine-led for children's activities. Those behaviours in Strategy B reflect child choice and self-governance, and absence of parental regulation; they are analogous to routine-free parenting for children's sleep and diet, hence they are termed routine-free for children's activities.

Table 7.19: Parenting Behaviours Reflecting Different Strategies for Children's Activities

Topic	Parenting Behaviours for Child Activities	
	Parenting Strategy A: "Routine-Led"	Parenting Strategy B: "Routine-Free"
Encouragement of Activities	Parent schedules child-centred activities each week, or provides time for child-centred activities weekly (n=64)	Parent does not schedule or provide time for weekly child-centred activities (n=44)
Restriction of TV Viewing	Parent restricts TV viewing (or would do if child wanted to watch more) (n=46)	Parent does not restrict TV viewing (n=56)

Associations amongst the parenting behaviours for each strategy regarding children's activities are shown in Table 7.20.

Table 7.20: Associations of Parenting Behaviours Regarding Child Activities

Chi-Square, X^2	*Encouragement of Activities (weekly child-centred activities versus no weekly child-centred activities)*
Restriction of TV Viewing (yes (or would) versus no)	11.44 ***

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

See Appendix L: Frequency Table for Association of Parenting Behaviours for Child Activities

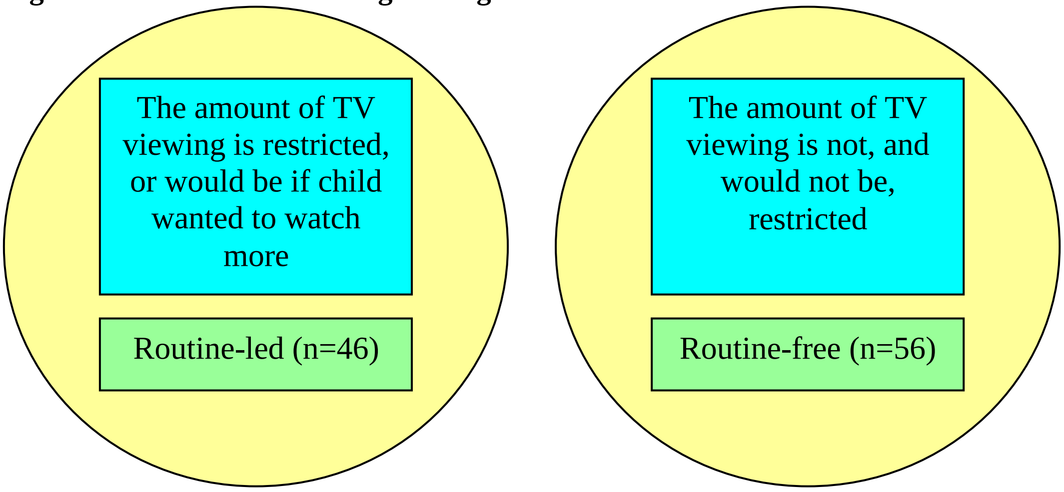
Routine-led parenting behaviours for children's activities were correlated together, and routine-free parenting behaviours were correlated together. This supports the idea that there are two distinct strategies for children's activities: one which encourages and restricts certain activities as optimal for their children; and one which does not regulate children's activities, either because of convenience, or so that children can choose for themselves what they do.

Since parenting behaviours in each strategy are significantly associated together, restriction of TV viewing will be used to represent parents' strategy for activities. Parents' restriction of TV viewing, or intent to restrict it if children wanted to watch more, will represent routine-led parenting for children's activities, and no restriction or intent to restrict TV viewing will represent routine-free parenting for children's activities.

Summary: Parents' Attitudes and Behaviours Regarding Children's Activities

General variation in parents' attitudes and practices regarding activities was identified: routine-led parents encouraged certain activities and restricted others (specifically TV viewing), since they prioritised activities which they considered to be good for their children's health and development, and spending time with their family. Routine-free parents were less regulatory of children's activities: they prioritised child choice and convenience, or their own schedules, rather than structuring their children's time and activities. Routine-led parenting behaviours were correlated together, and routine-free behaviours were correlated together; restriction of TV is representative of routine-led (do restrict TV viewing, or intend to if children want to watch more) versus routine-free parenting strategies (do not restrict, or intend to restrict, TV viewing) for children's activities, as shown in Figure 7.6.

Figure 7.6: Different Parenting Strategies for Children's Activities



Examination of Parenting Strategies for Children's Activities

This section will explore the parenting strategies for children's activities identified in the previous section. Associations of parenting strategy with children's TV viewing (and consequential risk for obesity) will be investigated, and variation in parenting strategies with SES and ethnicity will be assessed.

Parenting Strategies for Activities and Children's TV Viewing

TV viewing was compared between children whose parents were routine-led versus routine-free for activities (see Table 7.21).

Table 7.21: Comparison of Child TV Viewing with Parenting Strategy for Activities

Mann-Whitney U, Chi-Square	Parenting Strategy Regarding Child Activities: Routine-Led (n=46)	Routine-Free (n=56)	X^2 or U Statistic	p value
Weighted Mean TV Viewing Duration (mins) (median (range))	71 (9-219)	92 (1-323)	U=606	.067
Latest TV Viewing Time (hh:mm) (median (range))	18:52 (12:10-21:00)	19:17 (8:25-21:45)	U=505	.025
TV in the Bedroom (%)	28	56	X^2=8.05	.005

Children whose parents were routine-free for activities watched TV until later in the evening, and were more likely to have a TV in their bedroom, compared to children of routine-led parents. They watched more TV per day, but this difference did not reach significance.

The association of parenting strategy with time of cessation of TV viewing but not with overall TV viewing duration suggests a particular association of parenting with evening TV viewing. TV viewing in the evening in particular is negatively associated with children's sleep (see Chapter 3); hence the later TV cessation time for children of routine-free parents may be important for the sleep-obesity link: this will be explored further in Chapter 8.

Since presence of a TV in the bedroom during the preschool years is a risk factor for childhood obesity (see Chapter 3), these results suggest that children of routine-free parents had TV viewing habits which put them at a greater risk for becoming obese compared to children of routine-led parents.

The suggestion that parenting strategy is associated with children's TV viewing supports previous studies. In school-aged children, limitation of TV time by parents was correlated with significantly less TV viewing in children compared to those whose TV was not limited (Wiecha et al., 2001); and rules and restrictions on children's electronic media use were associated with lower levels of TV and computer use (Van den Bulck & Van den Bergh, 2000). Also in school-aged children, Davison et al. (2005) found that children whose parents did not limit their access to TV watched significantly more TV compared to those whose access was limited. Salmon et al. (2005) found that children were likely to watch less TV if their parents restricted TV during meals, but there was no association with TV restriction or supervision generally throughout the day.

Regarding physical activity, in Latino children as young as preschool age, parental use of positive reinforcement and monitoring has been found to be positively associated with physical activity; however, limit setting, including restriction of TV viewing, was not (Arrendondo et al., 2006).

The results reported here, although not matching previous studies in terms of TV viewing duration or physical activity outcomes specifically, are in keeping with the positive association of parental regulation of activities with increased physical and decreased sedentary activities.

SES and Parenting Strategy for Activities

Frequencies of parenting strategies for children’s activities in each SES group were compared (see Table 7.22).

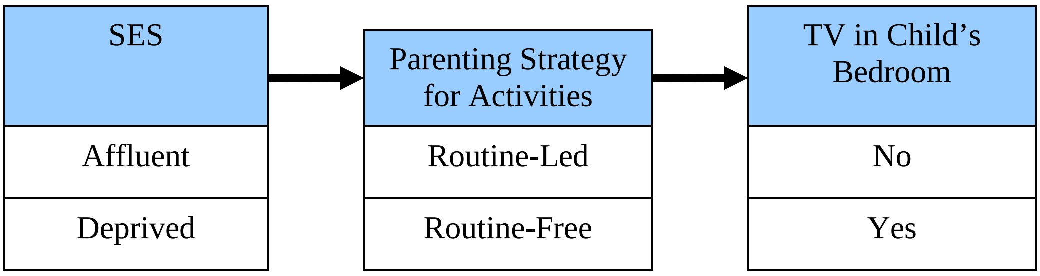
Table 7.22: Frequencies of Parenting Strategies for Activities in each SES Group

Parenting Strategy for Activity	SES		X^2	p value
	Affluent	Deprived		
Routine-Led (n)	29	17		
Routine-Free (n)	19	37	8.59	.005

Parents who were routine-led for children’s activities were significantly more likely to live in affluent areas, whilst routine-free parents were more likely to live in deprived areas. This is consistent with the distribution of routine-led and routine-free parenting strategies for both sleep and activity across SES groups (see Chapter 6, and above).

Again, direction of causality is most likely to be SES influencing parenting strategy. Since SES and parenting strategy are significantly associated, and both are correlated with children having a TV in their bedroom, there may be mediation between the variables, as shown in Figure 7.7.

Figure 7.7: Possible Mediation of SES-TV Habits Association by Parenting Strategy



Parenting strategy was associated with time of latest TV viewing only, and SES was associated with TV viewing duration only, and so mediation is not evident for these variables in this study, but should be considered in future studies.

Ethnicity and Parenting Strategy for Activities

Frequencies of parenting strategies for children's activities in each ethnic group were examined (see Table 7.23).

Table 7.23: Frequencies of Parenting Strategies for Activities with Ethnicity

Parenting Strategy for Child Activities	Ethnicity	
	White British	BME
Routine-Led (n)	39	7
Routine-Free (n)	52	4

25% cells have expected count less than 5, so statistical associations cannot be performed

Frequencies of BME families were too low for statistical comparisons to be made with white British families. However, the frequencies indicate that BME parents were more likely to be routine-led whilst white British parents were more likely to be routine-free for children's activities. This is the opposite pattern to children's sleep and diets, where BME parents were more frequently routine-free, and white British parents were more frequently routine-led.

Cross-cultural variation in parents' restriction of TV viewing has previously been reported: amongst middle class, well educated parents of 3-5 year-old children, American parents reported more supervision of children's TV viewing, whilst Japanese mothers imposed fewer restrictions (Komaya & Bowyer, 2000). Again, further research into ethnic variation in parenting strategies may aid understanding of variation in parenting behaviours, and the influence of parenting and ethnicity on children's health.

Summary: Examination of Parenting Strategies for Children's Activities

Children of routine-led parents for activity stopped watching TV earlier in the evening, and were less likely to have a TV in their bedroom compared to children of routine-free parents. This supports an association of routine-free parenting with obesity-promoting TV viewing habits. Similarly to sleep and diet, routine-led parenting for activities was more frequent in affluent areas, and routine-free parenting was more prevalent in deprived areas.

Section Summary: Activity

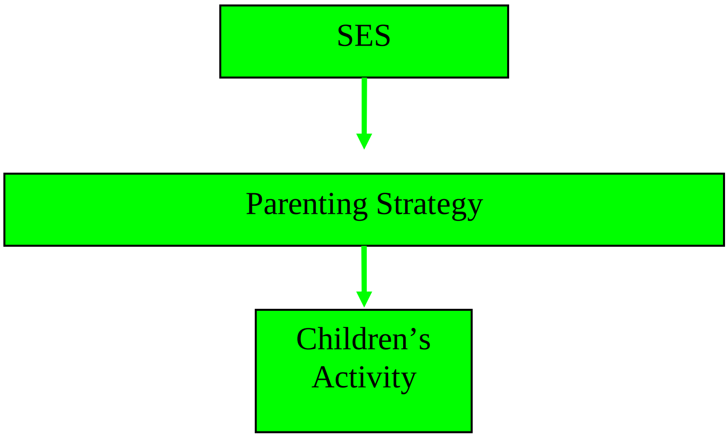
This section of the chapter examined children's physical and sedentary activity patterns, parents' attitudes and practices regarding children's daily and weekly activities, and associations of parenting with children's activity. Due to concerns regarding consistency and accuracy of data, physical activity durations were not considered in analyses; physical activity patterns should be considered in future research into the sleep-obesity link. Distinct parenting strategies for children's activities were identified: routine-free parenting was associated with obesity-promoting TV viewing habits compared to routine-led parenting, suggesting an association of parenting strategy with children's (sedentary) activity patterns. Routine-led parenting for children's activities was more frequent in affluent areas, whilst routine-free parenting was more frequent in deprived areas, suggesting a potential mediating role of parenting in associations of SES with children's activity.

Although the exploratory and cross-sectional design of this study means that associations and direction of causality cannot be confirmed, based on the results presented in this section of the chapter, in addition to the literature reviewed in Chapters 2 and 3, I have formulated Model C, as shown in Figure 7.8. This model will be expanded on and discussed in the remainder of this chapter and the following chapters.

Figure 7.8: Model C

Children's activity is influenced by parenting strategy (routine-free parenting is associated with obesity-promoting children's activity habits compared to routine-led parenting).

Parenting strategy mediates the relationship between SES and children's activity (higher SES parents are more likely to be routine-led, and lower SES parents are more likely to be routine-free; children in lower SES groups have relatively obesity-prompting activity patterns compared to those in higher SES groups).



Parenting Strategy and Children's Risk of Obesity

The final section of this chapter will examine associations of parenting strategies for children's diets and activities with children's body composition, in order to further explore associations of parenting with children's risk of obesity.

Parenting Strategies for Diet and Activities and Children's Body Composition

This chapter has suggested that routine-free parenting is associated with obesity-promoting children's dietary and activity behaviours, whilst the dietary and activity behaviours of children of routine-led parents are relatively obesity-protective. In order to assess any associations of parenting strategies with obesity directly, body composition SD scores were compared between children of routine-led versus routine-free parents for diet and activity (see Table 7.24).

Table 7.24: Associations of Children's Body Composition with Parenting Strategies for Diet and Activities

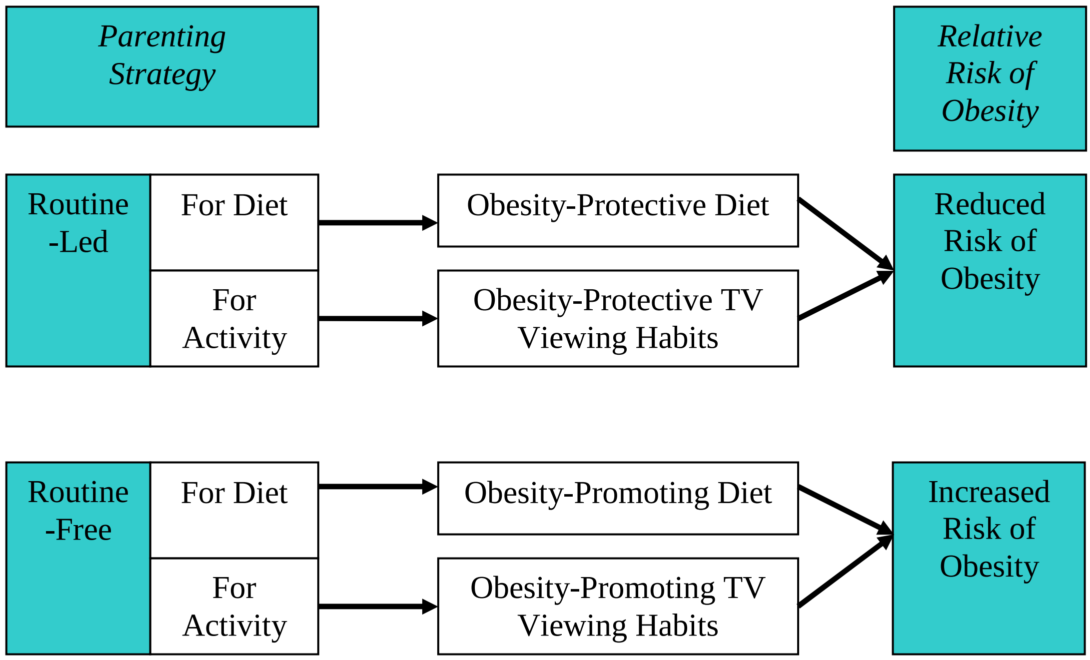
Independent t-test	*Parenting Strategy Topic*	Parenting Strategy: Routine-Led (diet n=63 activities n=46)	Parenting Strategy: Routine-Free (diet n=45 activities n=56)	t Statistic	p value
BMI SD Score (mean (SD))	*Diet*	.30 (.85)	.49 (.97)	-1.03	.307
	Activity	.09 (.81)	.64 (.94)	-2.97	.004
Waist Circumference SD Score (mean (SD))	*Diet*	.62 (.77)	.55 (.95)	0.41	.684
	Activity	.34 (.65)	.81 (.97)	-2.68	.009
Triceps Skinfold SD Score (mean (SD))	*Diet*	1.15 (.93)	1.18 (.98)	-0.17	.869
	Activity	1.01 (1.02)	1.27 (.91)	-1.32	.190
Subscapular Skinfold SD Score (mean (SD))	*Diet*	-.14 (1.06)	.53 (1.04)	-2.49	.015
	Activity	-.20 (.90)	.59 (1.09)	-3.73	<.000

Children whose parents were routine-led for diet and activities had lower subscapular skinfold SD scores compared to those whose parents were routine-free; children of routine-led parents for activities also had lower BMI and waist circumference SD scores.

Hence routine-led parenting is associated with lower body composition SD scores, and therefore reduced risk of obesity for children. These results support previous findings of an association of parenting styles with children's risk of obesity (see Chapter 3). For example, studies by Wake et al. (2007) and Rhee et al. (2006) found parenting styles characterised by low control to be associated with increased odds of obesity for preschoolers. Although levels of warmth are also important for children's obesity risk (see Chapter 3), and warmth in parenting cannot be determined in this sample, the associations of routine-led parenting with lower body composition SD scores are consistent with the control aspect of parenting styles predicting lower BMI in these studies.

Since routine-free parenting strategies for diet and activity were associated with dietary and activity behaviours which are thought to increase risk of obesity, perhaps the association of parenting strategy with body composition reported here is due to mediation by dietary and activity obesity-promoting behaviours, as shown in Figure 7.9.

Figure 7.9: Possible Association of Parenting Strategy with Children's Risk of Obesity, Mediated by Dietary and Activity Behaviours



Summary: Parenting Strategy and Children's Risk of Obesity

Routine-led parenting for both diet and activities was associated with lower child body composition SD scores compared to routine-free parenting. Coupled with the associations of parenting strategies with children's food intake and TV viewing, this further suggests that children of routine-free parents are at greater risk for obesity compared to children of routine-led parents, and suggests a mediating role of dietary and activity behaviours in the parenting-childhood obesity relationship.

Chapter 7 Summary: Diet and Activity

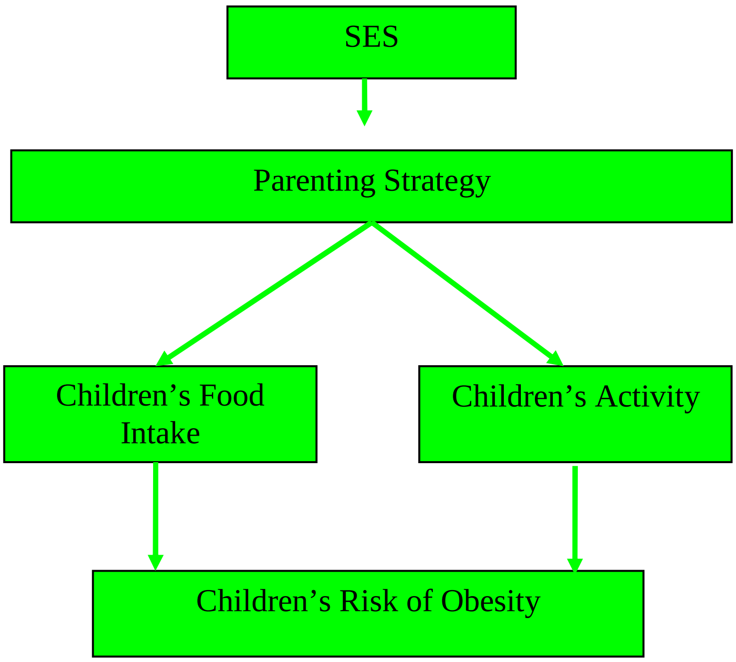
This chapter examined children's diets and activity patterns, parents' attitudes and practices regarding children's diets and activity, and associations of parenting with children's food intake, TV viewing, and body composition. Compared to routine-led parenting, routine-free parenting for diet and activity was associated with more obesity-promoting food intake and TV viewing behaviours for children respectively, and with greater body composition SD scores. Furthermore, routine-led parenting was associated with affluent households, and routine-free parenting with deprived households. Perhaps parenting strategy mediates associations of SES with children's food intake, activities, and risk of obesity.

Again, the exploratory and cross-sectional design of this study means that associations and direction of causality cannot be confirmed. Based on the results presented in this chapter (Models B and C), in addition to the literature reviewed in Chapters 2 and 3, I have formulated Model D, as shown in Figure 7.10. This model will be expanded on and discussed in the following chapter, and will be interpreted using an evolutionary perspective in Chapter 9.

Figure 7.10: Model D

Parenting strategy impacts children's risk of obesity, via food intake and activity patterns (routine-free parenting is associated with obesity-promoting children's food intake and activity patterns compared to routine-led parenting).

Parenting strategy mediates the relationship between SES and childhood obesity (higher SES parents are more likely to be routine-led, and lower SES parents are more likely to be routine-free; children in higher SES groups are at greater risk for obesity compared to those in lower SES groups).



The next chapter will explore mechanisms by which children's sleep may be linked to risk of obesity via dietary and activity behaviours, and the potential role of parenting strategies.

Chapter 8: Mechanisms Linking Children's Short Sleep and Obesity

This chapter will examine behavioural mechanisms by which children's sleep duration may be linked to risk of obesity via diet and activity, thereby addressing primary aim one. In order to do this, associations of children's sleep with food intake and TV viewing (and consequential risk of obesity) will be examined, focusing on potential mechanisms suggested in Chapter 3. Then, associations of children's sleep with diet and activity patterns via parenting strategy will be considered. Exploration of the role of parenting strategy in the childhood sleep-obesity link, and variation in parenting strategies will address primary aim two. This chapter will continue to address primary aim three by incorporating ethnicity and SES into analyses, and describing attitudes and values in relation to parenting.

Role of Behavioural Mechanisms in the Childhood Sleep-Obesity Link

This section of the chapter will explore potential behavioural mechanisms linking children's short sleep with risk of obesity, in order to address primary aim one. It will do so by examining associations of children's sleep with food intake and activity behaviours, focusing on the potential mechanisms suggested in Figure 3.2 (Chapter 3). Specifically, this section will a) describe variation in children's appetite and foods consumed in relation to sleep, b) examine associations of sleep with morning food consumption (breakfast), c) examine associations of sleep with evening food consumption (supper; timing of the evening meal), d) examine associations of sleep with total duration and particularly evening timing of TV viewing, and e) examine variation in sleep between children with and without a TV in their bedroom.

Children's Sleep and Appetite

During interviews, 8 parents spontaneously discussed the relationship between their children's sleep and food intake (see Figure 8.1).

Figure 8.1: Parents' Descriptions of the Link between Children's Sleep and Food Intake

Parents' Descriptions of Children's Sleep and Appetite being Linked

"If he's tired, he doesn't seem to eat in the morning." (ID 15)

"Not having sleep, messing up sleep, stops children eating." (ID 65)

"He doesn't eat as much when he's tired." (ID 104)

"If he's tired, he can't be bothered to eat." (ID 60)

"When he's overtired… he won't eat." (ID 48)

"If they don't sleep, they don't eat." (ID 74)

"When they [children] don't sleep well and are tired, they don't eat well – they lose interest and want to wander off." (ID 56)

"If he has a good night's sleep he'll eat his breakfast in the morning." (ID 46)

All 8 parents said that when their children do not sleep well or are tired, then they do not eat. This appears to be paradoxical to the sleep-obesity link, which suggests that children who sleep for less may eat more, or have more obesity-promoting diets. However, these descriptions suggest that if they do not sleep well or for long, then children do not want to eat breakfast: lack of breakfast is associated with increased risk of obesity (Chapter 3), and so this effect on appetite in the morning could potentially lead to obesity. A study is currently being conducted to formally examine potential variation in school-aged children's appetite and food preferences following sleep restriction and extension (Chantelle Hart, personal communication): perhaps children crave other foods through they day when are tired, or their appetite throughout the day is altered. Future research into the association of short sleep with children's appetite and food choices, particularly in preschool children, could further understanding of the mechanisms linking children's sleep with risk of obesity.

One mother mentioned the effect on her own appetite and food preparation when she is tired:

"If you're tired it affects your appetite, you want sugary things. And you just want to grab the first food you can, not prepare anything." (ID 54)

This may influence the food which she provides her daughter; for example, she may not make homemade meals when she is tired, and instead serve her daughter pre-prepared foods. This is consistent with reports that sleep restriction influences appetite in adults (see Chapter 2), and further suggests that short sleep duration in parents may influence children's food intake via parents' food choices and preparation effort. Future research could examine associations between parents' sleep, their children's food intake, and their children's risk of obesity.

Whilst parents' quotes in Figure 8.1 describe sleep influencing food intake, two other parents reported an effect of food intake on sleep for their children:

"They shouldn't eat at night, 'cause it'll stop them sleeping. I [mum] brought tea forward from 5 to 4:30 and I think it's contributed to them sleeping better." (ID 3)

"From about 6pm I [mum] say no if he wants chocolate… He can have fizzy drinks in the morning but not in the evening. The doctor said that fizzy drinks and chocolate keep children awake." (ID 37)

Children's Sleep and Food Intake

Associations of children's sleep with dietary intake were examined (see Table 8.1). Bedtime was significantly negatively correlated with daily servings of fruit and vegetables, positively correlated with daily servings of pre-prepared foods, and was significantly later in children who consumed carbonated drinks compared to those who did not (20:21±1:02 versus 19:36±0:47). Nighttime sleep duration was significantly shorter for children who consumed at least one carbonated drink compared to those who consumed none (656±38mins versus 680±35mins); there was no variation in food intake with napping or total daily sleep duration.

Table 8.1: Associations of Servings of Food Groups with Bedtime and Sleep Durations

Spearman's Correlations, Pearson's Correlations, Independent t-test, Mann-Whitney U	Mean Daily Servings of Fruit & Vegetables (n=90)	Mean Daily Servings of Pre Prepared Foods (n=89)	Mean Daily Servings of Sweets (n=88)	Consumed Carbonated Drinks (Yes n=22 versus No n=60)
Weighted Mean Bedtime	r_s=-.29 *	r_s= .27 *	r= .01	t= -3.15 **
Weighted Mean Nighttime Sleep Duration	r_s= .17	r_s=-.19	r=-.06	t=2.57 *
Weighted Mean Daily Nap Duration	r_s=. 00	r_s= .08	r_s= .09	U=492
Weighted Mean Total Daily Sleep Duration	r_s =. 15	r_s =-.15	r=-.04	t=1.87

* p≤ .05 ** p≤ .01 *** p≤ .001

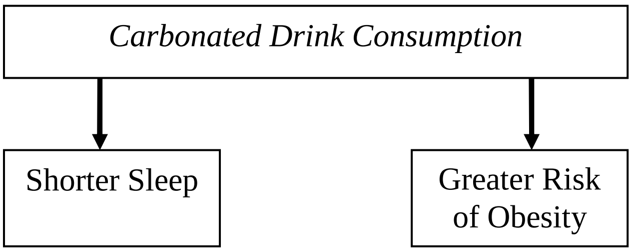
The inverse correlation of bedtime with fruit and vegetables and positive correlation with pre-prepared foods supports previous findings in adults of an association of short sleep duration with less healthful diets (see Chapter 3); specifically decreased fruit and vegetable consumption and increased fat intake and frequency of fast food (Shi et al., 2008, Stamatakis & Brownson, 2008).

In sum, earlier bedtimes and longer nighttime sleep duration were associated with obesity-protecting dietary habits, whilst later bedtimes and shorter nighttime sleep duration were associated with obesity-promoting dietary habits. This suggests a pathway through which short sleep and increased risk of obesity may be linked via consumption of obesity-promoting foods (see Figure 8.2) (note: bi-directionality of arrows indicates that direction of causality is unknown).

Figure 8.2: Potential Mediation of Food Intake Patterns in the Sleep-Obesity Link

The association of carbonated drink intake with later bedtimes and reduced nighttime sleep is consistent with recommendations that caffeine consumption, including carbonated drinks, be avoided in children, especially late in the day, since it may disrupt sleep onset and sleep quality (Mindell et al., 2009a), and has been associated with shorter nighttime sleep in school children (Pollak & Bright, 2003). Since carbonated drinks and their associated caffeine content are associated with shorter sleep, and also with risk of obesity, carbonated drink intake may confound the sleep-obesity association (see Figure 8.3). Further research is needed to examine carbonated drinks as a contributor to the sleep-obesity link, and to establish causality in associations.

Figure 8.3: Potential Confounding of the Sleep-Obesity Link by Carbonated Drink Consumption



Longer time awake and more opportunity for food consumption in shorter sleepers (particularly in the evening) has been hypothesised as a pathway linking short sleep to obesity (see Chapter 3). However, the inverse association of bedtime with servings of fruit and vegetables reported here demonstrates that not all foods were consumed in greater quantities by children who stayed up later in the evening, and some were consumed less. It appears that later bedtimes and shorter sleep were associated with greater consumption of specifically obesity-promoting foods only, and inversely associated with obesity-protecting fruit and vegetables.

Since parenting influences the types of foods eaten by children (Chapter 7), and children's appetite for food types can only impact on food intake if parents enable children to consume their preferred foods, parental behaviours regarding children's diets are likely to be involved in any associations of sleep with appetite and food intake. This is explored later.

Children's Sleep and Food Distribution through the Day

Distribution of food throughout the day was suggested in Chapter 3 to be a possible factor linking short sleep and obesity. Specific suggestions were breakfast consumption and evening food consumption. Associations of breakfast consumption with sleep are shown in Table 8.2.

Table 8.2: Associations of Frequency of Breakfast Consumption with Children's Sleep

Independent t-test, Mann-Whitney U	Breakfast Consumption: Always Eats Breakfast (n=79)	Breakfast Consumption: Doesn't Always Eat Breakfast (including when offered) (n=29)	t or U Statistic	p value
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:42 (0:44)	20:03 (1:12)	t= -1.48	.143
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	676 (35)	662 (43)	t=1.45	.150
Weighted Mean Daily Nap Duration (mins) (median (range))	0 (0-65)	3 (0-113)	U= 629	.436
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	685 (35)	676 (36)	t=1.03	.304

There were no significant differences in sleep variables between children who did eat breakfast every day, and who did not eat breakfast every day (either because their parents did not provide it, or because their parents did provide it but they would not eat it).

Despite the lack of significant differences, parents who mentioned during interviews that their children do not eat as well when they are tired sometimes specifically mentioned their not eating well at breakfast or in the morning (see Figure 8.1). Further investigation into associations of sleep with food intake should examine variation in the types of foods eaten at breakfast, the quantity of food eaten, and the timing of breakfast.

Since more evening food consumption was a factor suggested in Chapter 3 to potentially be involved in the short sleep-obesity link, comparisons were made in sleep variables between children who ate supper less than weekly versus more than weekly (see Table 8.3) (supper was defined as food eaten after the main evening meal, before going to sleep). There were no significant differences in sleep duration; but children who ate supper more than weekly had later bedtimes. Future research could examine whether the additional activity of consuming supper delays bedtimes directly, causing later bedtimes for children who consume supper.

Table 8.3: Associations of Frequency of Supper Consumption with Children's Sleep

Independent t-test, Mann-Whitney U	Frequency of Supper		t or U Statistic	p value
	Less Than Weekly (n=38)	More Than Weekly (n=60)		
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:33 (0:54)	19:59 (0:51)	t= -2.02	.048
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	681 (47)	665(31)	t=1.75	.084
Weighted Mean Daily Nap Duration (mins) (median (range))	3 (0-113)	1 (0-65)	U= 650	.841
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	690 (41)	676 (30)	t=1.69	.095

Although the provision of a small, healthy snack before going to bed (for example fruit or yoghurt) is recommended to aid child sleep, the consumption of large meals close to bedtime, and of caffeine-containing food and drink, is recommended against due to adverse consequences for sleep (Mindell et al., 2009a; Taheri, 2006). In this sample, the types of foods consumed by children before bed as documented in the diaries varied from fruit and yoghurt, cereal and toast, to sweets, biscuits, ice cream, chips and pizza. Of the children who ate supper during the diary period, 77% ate something other than fruit, cereal, toast or yoghurt. Further research is needed to investigate the quantity, timing and types of foods eaten in the evening. Research could explore whether suppers are obesity-promoting in content, or whether frequent supper consumption indicates a more obesity-promoting dietary pattern in general.

Another aspect of evening food intake is timing of the main evening meal (see Chapter 3). Descriptive data regarding the time at which the evening meal was eaten (weighted mean) are shown in Table 8.4.

Table 8.4: Time of Evening Meal: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Weighted Mean Time of Evening Meal (hh:mm)	82	16:00	19:09	17:14	00:35	17:12

Associations of evening meal time with sleep are shown in Table 8.5. Children who ate their evening meals later in the evening did not take longer to get to sleep once getting into bed, but they did go to bed later. Timing of the evening meal was also significantly negatively correlated with nighttime and total daily sleep duration, and positively correlated with daily nap duration. This suggests an association of timing of the evening meal with sleep, which may be important for the sleep-obesity link.

Table 8.5: Associations of Time of Evening Meal with Children's Sleep

Spearman's Correlations, Pearson's Correlations	Weighted Mean Time of Evening Meal
Weighted Mean Sleep Onset Latency (mins) (n=58)	r_s=.21
Weighted Mean Bed Time (hh:mm) (n=73)	r= .46 ***
Weighted Mean Nighttime Sleep Duration (mins) (n=84)	r=-.42 ***
Weighted Mean Daily Nap Duration (mins) (n=84)	r_s=.31 **
Weighted Mean Total Daily Sleep Duration (mins) (n=84)	r=-.27 *

* p≤ .05 ** p≤ .01 *** p≤ .001

The composition of the evening meal (for example calorie content) is not determinable in this study. Further research is needed to consider the association of timing of the evening meal with dietary quality and obesity risk; also the relationship with sleep (including direction of causality), and impact on the sleep-obesity association.

During interviews, some parents discussed regular meals and mealtimes being a component of general regulation and routines. This was particularly marked in the evening: for example, some parents described timing of evening food intake and bedtime being interlinked as part of the evening schedule:

"Tea at 4pm, supper at 6pm, then bath and bed, pretty much on the dot." (ID 96)

Bedtime could influence evening food intake and timing of food consumption:

"He doesn't really eat after 6pm – I [mum] don't want it lying on his stomach." (ID 94)

"I [mum] give them tea quite early – I don't want them going to bed on a full stomach." (ID 104)

Since qualitative data suggested that parental regulation and routines during the evening impacts on the time at which the evening meal is served, associations of timing of the evening meal with parenting strategy for sleep were examined (see Table 8.6). The evening meal was consumed later by children of routine-free compared to routine-led parents for sleep. This supports an association of earlier evening mealtimes with parental regulation, limit-setting and consistency in the evening.

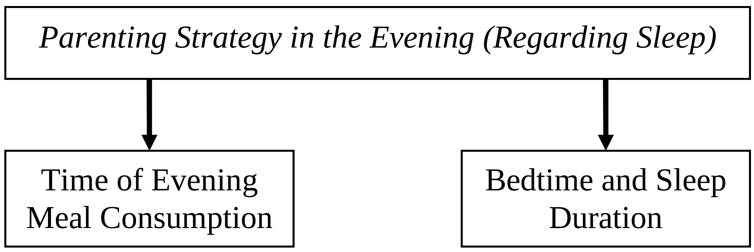
Table 8.6: Associations of Time of the Evening Meal with Parenting Strategies for Sleep

Independent t-test	Parenting Strategy for Sleep		t value	p value
	Routine-Led (n=82)	Routine-Free (n=26)		
Weighted Mean Time of Evening Meal (hh:mm)	17:08 (0:27)	17:33 (0:51)	-2.72	.008

As described in Chapter 6, napping was associated with lack of regulation by parents, and a more laissez-faire attitude: the positive association of time of the evening meal with daily napping duration in this sample (Table 8.5) supports the concept of later evening meal time reflecting lack of regulation, limit-setting and consistency in parents.

Although causality cannot be determined in this study, in combination with parenting strategy for sleep being associated with sleep duration (Chapter 6), these results suggest that timing of the evening meal may be associated with sleep due to mutual association with parenting strategy in the evening, as shown in Figure 8.4.

Figure 8.4: Potential Confounding Role of Parenting Strategy in the Association of Children's Time of Evening Meal Consumption with Sleep



Further research is needed to explore the association of timing of the evening meal with sleep, to help to elucidate whether the association is direct, whether it is due to the impact of parental regulation and routine-setting in the evening, and whether it may contribute to the sleep-obesity link.

The quantitative results presented here do not strongly support an association of either breakfast or supper consumption with sleep; but timing of the evening meal was negatively associated with nighttime and total daily sleep duration. Qualitative data suggested an association of sleep with breakfast consumption (see Figure 8.1), and of evening meal time with regulatory and consistent parenting in the evening. In combination with the literature documenting associations of daily food distribution with obesity risk, and potentially sleep (see Chapter 3), this suggests that there may be a role of daily food distribution in the sleep-obesity link. This should be explored in more detail in future studies, including nutritional content of these meals and whether they are obesity-promoting.

Children's Sleep and TV Viewing

Associations of children's sleep with daily TV viewing duration and latest time of TV viewing are shown in Table 8.7.

Table 8.7: Associations of Weighted Mean TV Viewing Duration and Latest TV Viewing Time with Children's Sleep

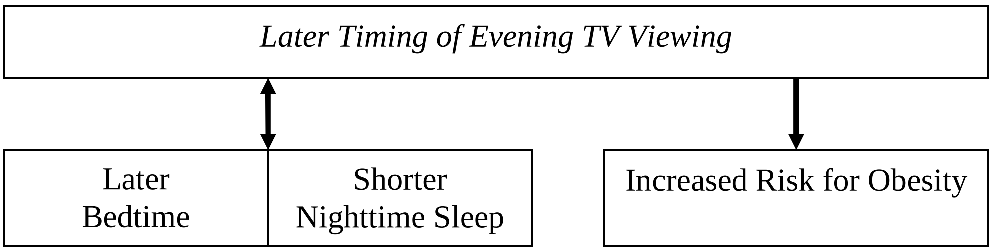
Spearman's Correlations, r_s	Weighted Mean TV Viewing Duration (n=85)	Latest TV Viewing Time (n=80)
Weighted Mean Bedtime	0.08	.37 **
Weighted Mean Nighttime Sleep Duration	0.13	-.29 *
Weighted Mean Daily Nap Duration	-0.19	0.19
Weighted Mean Total Daily Sleep Duration	0.06	-0.21

* p≤ .05 ** p≤ .01 *** p≤ .001

Whilst total daily TV viewing was not significantly correlated with sleep, latest time of TV viewing was significantly positively correlated with bedtime, and negatively correlated with nighttime sleep duration. Therefore TV viewing in the evening in particular, rather than overall TV viewing, appears to be associated with sleep in this sample. The importance of timing of evening TV viewing is in keeping with latest TV viewing time, but not total TV viewing duration, being associated with parenting strategy for children's activities (see Chapter 7).

The suggestion that TV viewing is implicated in the sleep-obesity link has been suggested but not supported in previous studies (see Chapter 3). The results here indicate that the timing of TV viewing may be particularly important, and is worthy of future research. Considering the observations in this study, and the literature outlined in Chapter 3, it is possible that evening TV viewing could confound the sleep-obesity link, as shown in Figure 8.5.

Figure 8.5: Potential Confounding Role of Evening TV Viewing in the Childhood Sleep-Obesity Link



Further research is needed to examine the factors associated with, and the impact of, evening TV viewing in preschool children; in particular the association of timing of evening TV viewing with sleep, and with obesity-promoting TV viewing habits and risk of obesity.

Children's Sleep and Presence of a TV in the Bedroom

Sleep was compared between children who did and did not have a TV in their bedroom (see Table 8.8).

Table 8.8: Associations of Presence of a TV in the Bedroom with Children's Sleep

Independent t-test, Mann-Whitney U	TV in the Bedroom		t or U Statistic	p value
	Yes (n=46)	No (n=62)		
Weighted Mean Bedtime (hh:mm) (mean (SD))	19:59 (1:00)	19:40 (0:47)	t= -1.48	.144
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	673 (27)	674 (43)	t=.12	.906
Weighted Mean Daily Nap Duration (mins) (median (range))	9 (0-59)	0 (0-113)	U=612	.042
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	685 (26)	681 (40)	t=-.46	.647

Daily nap duration was longer in children who had a TV in their bedroom. I suggested longer daily napping to be associated with lack of regulation and limit-setting by parents (Chapter 6); and having a TV in the bedroom was associated with routine-free parenting strategy for activities (Chapter 7). The correlation of napping with having a TV in the bedroom indicates the association of two factors reflective of lack of parental regulation and consistency.

There were no other significant differences in sleep, which is contrary to previous findings that having a TV in the bedroom is associated with less nighttime sleep in children (Owens et al., 1999b), including preschoolers (Mindell et al., 2009a; see Chapter 3).

Factors which may account for the lack of association of having a TV in the bedroom with sleep duration include: a) having a TV in the bedroom is more likely for children who share a bedroom, since the presence of a TV would be directly affected by the person with whom they share, and b) having a TV in the bedroom does not account for whether parents allow their children to watch this TV whilst they are in bed: during interviews, some parents said that they unplug the TV in their child’s bedroom so that they cannot watch it at night. The time that children watched TV until in the evening, rather than whether they had a TV in their bedroom, may therefore more closely reflect the TV viewing habits of children.

Summary: Role of Behavioural Mechanisms in the Childhood Sleep-Obesity Link

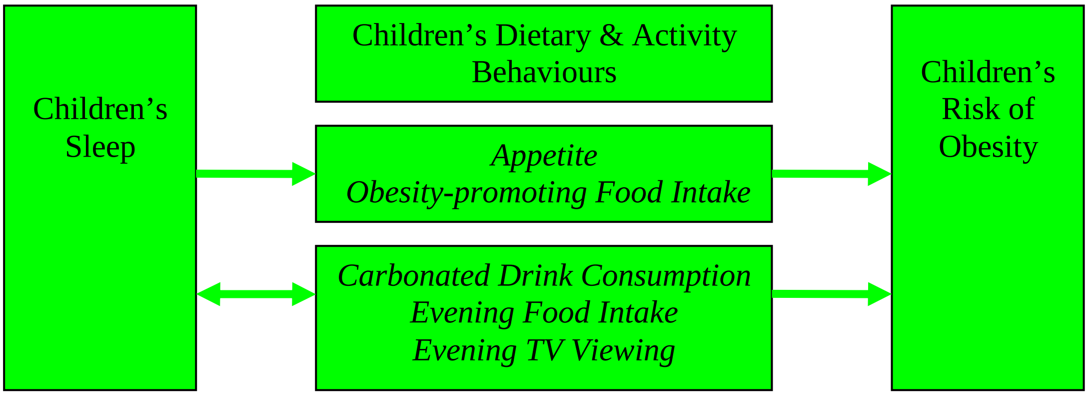
Later bedtimes and shorter nighttime sleep were associated with servings of food groups, suggesting that short sleep may be associated with increased risk of obesity due to mediation by the consumption of obesity-promoting foods. Parents suggested that sleep influences children’s appetite, and so appetite may be a mediating factor. Adverse associations of carbonated drink consumption with both sleep and risk of obesity may confound the sleep-obesity link. Food distribution through the day is another possible contributor: parents suggested that short or disrupted sleep leads children to eat less in the morning in particular; and more frequent consumption of supper was associated with later bedtimes. Later timing of the evening meal was associated with shorter sleep, perhaps due to an association with routine-free parenting for sleep.

Latest time of cessation of TV viewing was inversely correlated with sleep, so that children who watched TV until later in the evening had shorter sleep. The pattern of results suggests that timing of TV viewing, rather than overall TV viewing, may be important for sleep in this population.

This section has addressed primary aim one, and has suggested that there are some correlations of children's sleep with dietary and activity behaviours. Based on the results presented in this section of the chapter, in addition to the associations of dietary and activity behaviours with obesity risk and sleep which were suggested in Chapter 3, I have formulated the Behavioural Mechanisms Hypothesis, as shown in Figure 8.6. (Note: bi-directionality of arrows indicates where confounding is proposed, and single direction of arrows indicates where mediation is proposed.)

Figure 8.6: Behavioural Mechanisms Hypothesis

Dietary and activity behaviours contribute to the childhood short sleep-obesity relationship. Proposed mediating behaviours include appetite and obesity-promoting food intake; proposed confounding factors include carbonated drink consumption, distribution of food intake throughout the day (particularly timing of the evening meal); and evening TV viewing.

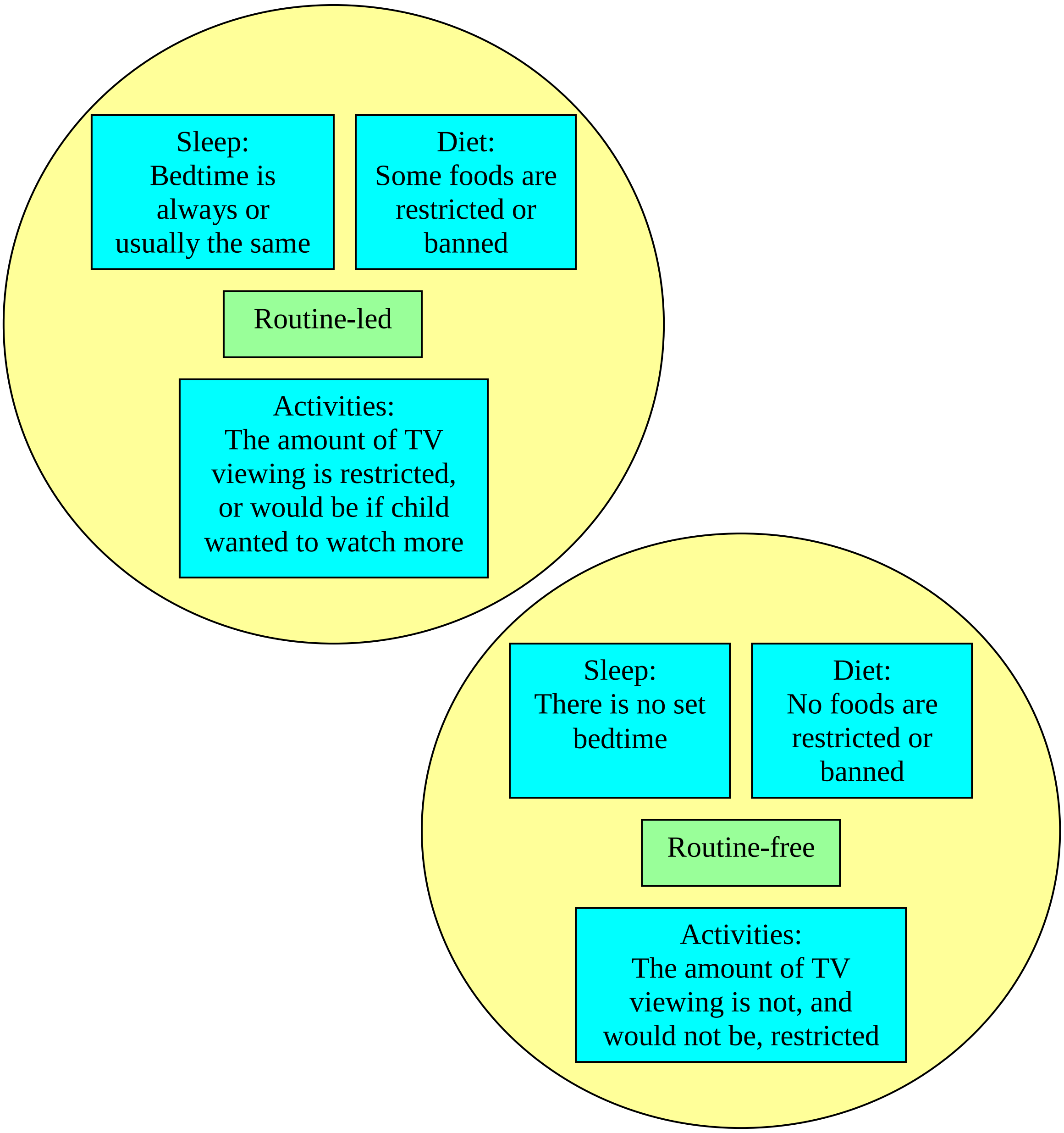


Further research is needed to understand more thoroughly the possible contributory role of diet and activity behaviours in the childhood sleep-obesity link. For example, research could examine whether children's appetite varies with sleep; what are the causal mechanisms between sleep and food intake; do timing of the evening meal and supper consumption delay bedtime and reduce sleep duration; and do the types of foods eaten during the evening specifically influence sleep and risk of obesity. Additionally, further research is needed into factors which are associated with evening TV viewing, and the role which evening TV viewing may play in the sleep-obesity link.

Role of Parenting in the Childhood Short Sleep-Obesity Link

This section of the chapter will explore the potential role of parenting strategy in the link between children's short sleep and risk of obesity (see Figure 8.7 for a summary of parenting strategies for children's sleep, diet and activities). Specifically, this section will a) examine associations of parenting strategy for sleep with children's food intake and TV viewing, and associations of parenting strategies for diet and activities with children's sleep, b) examine clustering of parenting strategies for each domain (sleep, diet activity), and c) consider the cumulative effect of parenting behaviours. In doing so, it will address primary aim two.

Figure 8.7: Summary of Parenting Strategies for Sleep, Diet and Activities



Parenting Strategy for Sleep and Children's Food Intake and TV Viewing

Associations of parenting strategy for sleep (routine-led versus routine-free) with children's food intake and TV viewing are shown in Table 8.9.

Table 8.9: Associations of Children's Food Intake and TV Viewing with Parenting Strategy for Sleep

Independent t-test, Mann-Whitney U, Chi-Square	Parenting Strategy Regarding Child Sleep: Routine-Led (n=82)	Parenting Strategy Regarding Child Sleep: Routine-Free (n=26)	t, U or X^2 value	p value
Daily Servings of Fruit & Vegetables (median (range))	1.5 (0-4.5)	1.25 (0-2.75)	U=503	.064
Daily Servings of Pre-Prepared Foods (median (range))	1.0 (0-3.0)	1.5 (.5-2.5)	U=468	.055
Daily Servings of Sweets (mean (SD))	1.32 (.76)	1.12 (.66)	t=1.04	.302
Consumed Carbonated Drinks (%)	19	59	X^2=10.9	.002
Weighted Mean TV Viewing Duration (mins) (median (range))	77 (15-323)	94 (1-285)	U=480	.244
Latest TV Viewing Time (hh:mm) (median (range))	19:00 (8:25-21:30)	19:30 (14:30-21:45)	U=393	.108
TV in the Bedroom (%)	40	50	X^2= .89	.369

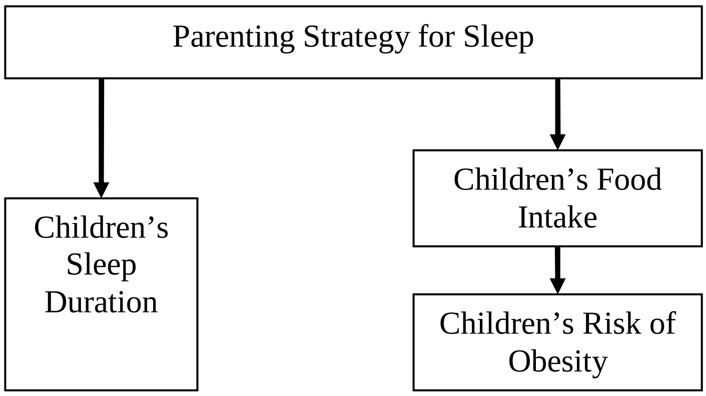
Children whose parents were routine-led for sleep were less likely to consume carbonated drinks compared to those whose parents were routine-free; there were no other significant differences in food intake, although there were trends for children of routine-led parents to be served more fruit and vegetables and fewer pre-prepared foods compared to children of routine-free parents. The lack of clear trend for servings of sweets is consistent with the finding that servings of sweets was not significantly correlated with parenting strategy for diet, whilst servings of pre-prepared foods and fruit and vegetables were (Chapter 7).

The results here suggest a more obesity-promoting diet for children whose parents were routine-free compared to routine-led for sleep. Coupled with the suggestion above, that timing of the evening meal may be linked to earlier bedtimes and longer sleep through parents' use of routines and regulations during the evening and at bedtime (because evening routines are likely to impact both bedtime and evening meal time), this suggests that use of routine-led parenting for sleep was associated with improved patterns of food intake.

Although there were trends for children of routine-free parents to watch more TV per day, watch TV until later in the evening, and be more likely to have a TV in their bedroom compared to children of routine-led parents, there were no significant differences in TV viewing with parenting strategy for sleep. This is not in support of Thompson & Christakis's (2005) finding that TV viewing duration was longer in children with irregular bedtimes. The results here suggest that evening TV viewing was not associated with parenting strategy and use of routines and regulation in the evening, meaning that children who watched TV until later in the evening may not have done so due to a lack of parental regulation and limit setting. Perhaps parents are unaware of the negative associates of evening TV viewing for sleep.

As described in Chapter 6, routine-led parenting for sleep was associated with earlier bedtimes, and longer nighttime and total daily sleep in children compared to routine-free parenting. Therefore routine-led parenting for sleep is associated with both longer sleep and a dietary pattern associated with reduced risk for obesity, and may explain some of the association of children's short sleep with risk of obesity (see Figure 8.8).

Figure 8.8: Possible Confounding Role of Parenting Strategy for Sleep in the Sleep-Obesity Link (via Food Intake)



Parenting Strategies for Diet and Activities and Children's Sleep

Associations of parenting strategies for both diet and activities with children's sleep are shown in Table 8.10.

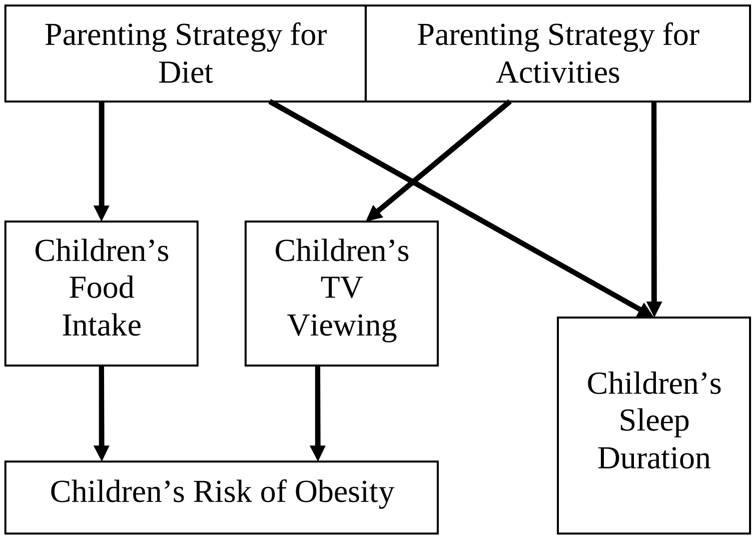
Table 8.10: Associations of Children's Sleep with Parenting Strategies for Diet & Activities

Independent t-test, Mann-Whitney U	*Parenting Strategy Topic*	Parenting Strategy: Routine-Led (diet n=63 activities n=46)	Parenting Strategy: Routine-Free (diet n=45 activities n=56)	t or U Statistic	p value
Weighted Mean Bedtime (hh:mm) (mean (SD))	*Diet*	19:40 (0:38)	20:02 (1:11)	t=-1.73	.088
	Activity	19:32 (0:33)	20:03 (1:06)	t=-2.47	.016
Weighted Mean Nighttime Sleep Duration (mins) (mean (SD))	*Diet*	681 (35)	657 (39)	t=2.86	.005
	Activity	682 (38)	665 (38)	t=2.03	.045
Weighted Mean Daily Nap Duration (mins) (median (range))	*Diet*	0 (0-65)	4 (0-113)	U=660	.135
	Activity	0 (0-59)	3 (0-113)	U=655	.148
Weighted Mean Total Daily Sleep Duration (mins) (mean (SD))	*Diet*	688 (35)	671 (34)	t=2.21	.030
	Activity	689 (37)	677 (33)	t=1.46	.147

Children whose parents were routine-led compared to routine-free for diet slept for longer at night and in total over the day; children whose parents were routine-led compared to routine-free for activities had earlier bedtimes and longer sleep at night.

As described in Chapter 7, routine-free parenting for diet was associated with an obesity-promoting diet compared to routine-led parenting (fewer servings of fruit and vegetables and more servings of pre-prepared foods), and routine-free parenting for activity was associated with obesity-promoting TV viewing habits (having a TV in the bedroom). Furthermore, routine-led parenting for both diet and activity were associated with lower body composition SD scores. Therefore, routine-led parenting for diet and activity is associated with both reduced risk for obesity and longer sleep in children; parenting may explain some of the association between children's sleep and risk of obesity (see Figure 8.9).

Figure 8.9: Possible Confounding Role of Parenting Strategies for Diet and Activities in the Sleep-Obesity Link (via Food Intake and TV Viewing)



Associations of Parenting Strategies for Sleep, Diet and Activities

Associations amongst parenting strategies for children's sleep, diet and activities are shown in Table 8.11.

Table 8.11: Associations of Parenting Strategies for Sleep, Diet and Activities

Chi-Square, X^2	*Parenting Strategy for Activities*	*Parenting Strategy for Diet*
Parenting Strategy for Sleep	12. 68 ***	20.37 ***
Parenting Strategy for Diet	17.54 ***	

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

See Appendix M: Frequency Tables for Associations of Parenting Strategies for Sleep, Diet and Activity

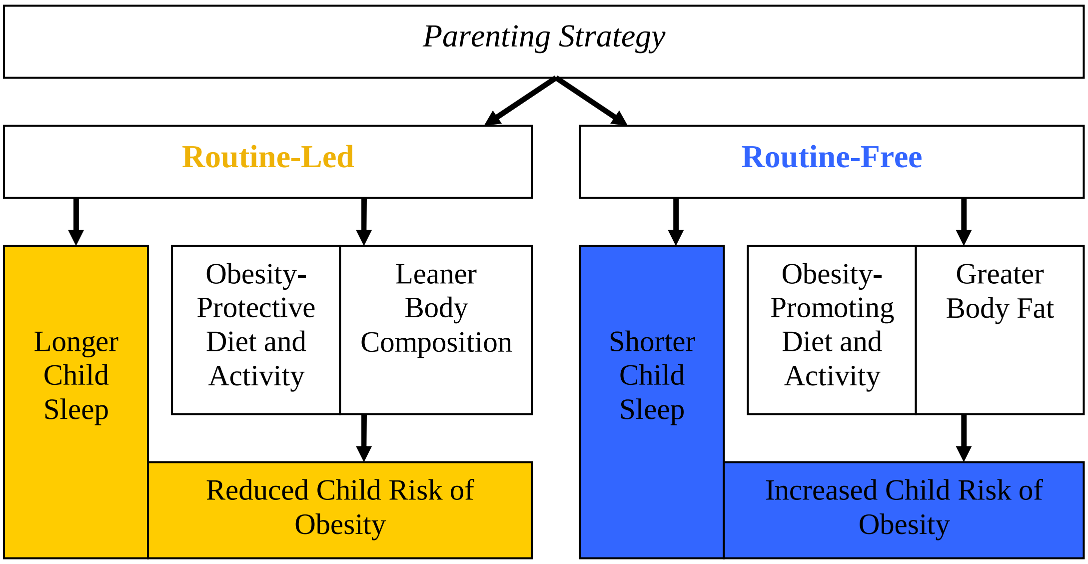
Routine-led parenting strategies were significantly correlated together, whilst routine-free strategies were significantly correlated together. This clustering of routine-led and routine-free strategies supports the concept that parents who cannot or do not maintain routine or limits in one aspect of lifestyle do not do so for others, and builds on the suggestion that parents who do not maintain regular TV viewing habits are less likely to maintain regular sleep schedules (Thompson & Christakis, 2005). Lack of regulation and routine in each aspect of lifestyle may reflect an overall level of chaos and lack of structure in the household, whilst routine and regulation reflects structure and lack of chaos, likely to co-occur in all areas of family lifestyle (Evans et al., 2005).

There have been previous suggestions that parenting style regarding diet is associated with overall parenting style (see Chapter 3): Hughes et al. (2005) demonstrated that authoritarian feeding styles were related to overall authoritarian parenting styles, and authoritative feeding styles were associated with generally higher parental control, structure, support and involvement. This is consistent with the findings reported for this study; that parental scheduling and regulatory behaviours for one aspect of child lifestyle are associated with scheduling and regulatory behaviours in other areas also. The results of this study suggest that the association of parenting styles for aspects of children's lifestyle extends to sleep.

Parenting Could Explain the Childhood Sleep-Obesity Link

In sum, parenting strategies regarding children's sleep, diet and activities were associated together, and with children's sleep duration and risk of obesity (food intake, TV viewing, and body composition). Specifically, routine-led parenting was associated with longer sleep and reduced risk of obesity (lower body composition SD scores, obesity-protective food intake and TV viewing habits); and routine-free parenting was associated with shorter sleep and increased risk of obesity (greater body composition SD scores and obesity-promoting food intake and TV viewing habits). Therefore parenting strategy may confound the association of children's short sleep duration with risk of obesity (see Figure 8.10).

Figure 8.10: Possible Confounding Role of Parenting Strategy in the Childhood Sleep-Obesity Link



The associations of parenting strategies and particularly the use of routines for different components of children's lifestyle (sleep, diet and activity) with both sleep and risk of obesity suggests the importance of overall parenting style for the sleep-obesity link, and for children's health. This builds upon the study of 8550 American preschool children (Anderson & Whitaker, 2010) which found prevalence of obesity to be inversely associated with exposure to three household routines for different areas of lifestyle: regularly eating dinner as a family, obtaining adequate nighttime sleep, and having limited screen-viewing time. The results presented here extend the associations of such routines to longer sleep, in addition to reduced risk of obesity.

Cumulative Effect of Routine-Led Behaviours

Anderson & Whitaker's (2010) study found that the number of routines to which children were exposed (between 0-3) was inversely associated with the prevalence of obesity. In order to explore the possibility of a cumulative effect of routine-led behaviours in this study also, the number of routine-led behaviours for each parent was examined. The individual behaviours originally identified as routine-led versus routine-free for sleep, diet and activity are shown in Table 8.12.

Table 8.12: Summary of Routine-Led and Routine-Free Parenting Behaviours

Parenting Behaviours	
Routine-Led	*Routine-Free*
Bedtime always or usually the same	No set bedtime
Parent usually reads to/with child at bedtime	Parent does not usually read to/with child at bedtime
Child did not fall asleep on the sofa at night	Child fell asleep on the sofa at least one night during the diary period
Child rarely gets into parents' bed during the night (less than weekly)	Child regularly gets into parents' bed during the night (at least weekly)
Parent restricts or bans certain foods totally	Parents does not restrict any foods
Child has no choice for meals	Child has some or free choice for meals
Child has no access to food, or access to fruit only	Child has free access to food
Parent tries to maintain regular meal times	Parent does not intent to maintain regular meal times
Child usually eats meals at a kitchen or dining room table	Child usually eats meals at a location other than a kitchen or dining room table
Parent schedules child-centred activities each week, or provides time for child-centred activities weekly	Parent does not schedule or provide time for weekly child-centred activities
Parent restricts TV viewing (or would do if child wanted to watch more)	Parent does not restrict TV viewing

The number of routine-led behaviours (between 0-11) was totalled for each parent (see Table 8.13 for descriptive statistics). Cronbach's alpha was .846, indicating that the sum of routine-led behaviours is a reliable scale variable.

Table 8.13: Sum of Routine-Led Parenting Behaviours: Descriptive Statistics

	n	Min	Max	Mean	SD	Median
Number of Routine-Led Parenting Behaviours	65	0	11	7.11	3.27	7.00

Associations of number of routine-led parenting behaviours with children's sleep, food intake and TV viewing were assessed (see Table 8.14).

Table 8.14: Associations of Number of Routine-Led Parenting Behaviours with Children's Sleep, Food Intake and TV Viewing

Spearman's Correlation r_s *Mann Whitney U*	Number of Routine-Led Parenting Behaviours (n=65)
Bedtime	r_s= -.38 **
Nighttime Sleep Duration	r_s= .32 *
Daytime Sleep Duration	r_s= -.30 *
Total Daily Sleep Duration	r_s= .27 *
Daily Servings of Fruit & Vegetables	r_s= .44 ***
Daily Servings of Pre Prepared Foods	r_s= -.25 *
Daily Servings of Sweets	r_s= -.02
Carbonated Drinks Consumed	U= 285
Daily TV Viewing Duration	r_s= -.27 *
Latest TV Viewing Time	r_s= -.32 *
TV in the Bedroom	U= 301 **
BMI SD Score	r_s= -.15
Waist Circumference SD Score	r_s= -.15
Triceps Skinfold SD Score	r_s= -.03
Subscapular Skinfold SD Score	r_s= -.41 **

* $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

As the number of routine-led parenting behaviours increased, the prevalence of obesity-promoting dietary and TV viewing habits decreased (servings of pre-prepared foods, daily TV viewing, TV in the bedroom), obesity-protective dietary habits increased (servings of fruit and vegetables), and there was a decrease in central fat (subscapular skinfold SD score). Consequently, as the number of routine-led parenting behaviours increased, the prevalence of obesity-promoting behaviours, and risk of obesity, decreased.

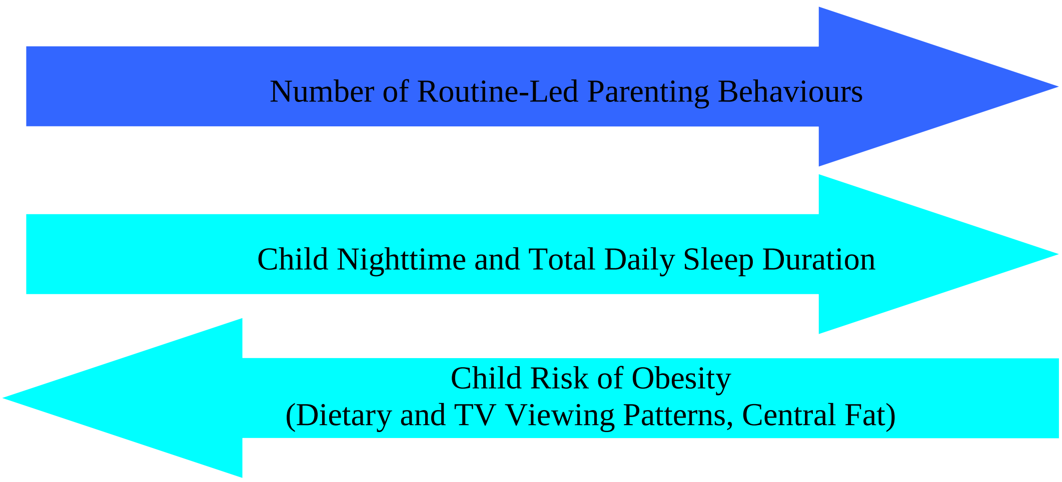
The significant association of servings of fruit and vegetables and pre-prepared foods, but not sweets or carbonated drinks, matches the pattern of correlations with parenting strategy for diet (Chapter 7). It was suggested that consumption of carbonated drinks was not associated with parenting strategy due to the large number of parents who did not report any drinks in the diaries, and the absence of fruit juices and other sugary drinks from analyses. Lack of association of servings of sweets was hypothesised to occur because routine-led parents often allowed sweet treats, leading to provision of sweets being less varied between routine-led and routine-free parents compared to other food groups; or because routine-free parents allowed their children to help themselves to sweet snacks without them knowing, hence might not be able to report their consumption accurately. Fruit and vegetables, and pre-prepared foods, may more accurately distinguish dietary patterns in this sample.

The significant association of number of routine-led parenting behaviours with subscapular skinfold SD score but not BMI, waist circumference or triceps skinfold SD scores, matches the significant association of sleep duration with subscapular skinfold SD score only, and again suggests the importance of central fat in particular.

At the same time that prevalence of obesity-promoting behaviours decreased, there was an increase in children's total sleep duration with increasing number of routine-led parenting behaviours. Nighttime and total daily sleep durations were positively correlated with number of routine-led parenting behaviours; daytime nap duration was negatively correlated, which is consistent with the theory that napping is associated with lack of regulation and limit-setting by parents (Chapter 6).

In sum, the inverse association of number of routine-led parenting behaviours with children's risk of obesity (via food intake, TV viewing, central fat), and positive association with sleep duration, suggests a cumulative association of routine-led parenting behaviours with both sleep and obesity risk (see Figure 8.11).

Figure 8.11: Possible Cumulative Effect of Routine-Led Parenting Behaviours on Children's Sleep Duration and Risk of Obesity



Parenting Behaviours and Child Health

Associations between parental regulation and child health have been established in previous studies. Monitoring in general positively influences child development by enhancing parental awareness of child location and activities, and alerting children that their parent is concerned, interested in and available to them (Leiferman et al., 2005). Monitoring is described by Leiferman et al. as a set of parenting practices which involves attention to where a child is and what they are doing, and is reflected in parent-child interactions and daily routines and activities: the routine-led behaviours identified in this study match these descriptions. Dishion & McMahon (1998) posit that parental monitoring is a necessary condition for effective parenting and improved child outcomes (regarding safety and behaviour of young children).

Unpredictability and lack of structure can have negative consequences during development by depriving children of predictable and sustained exchanges with people and their environment, which are crucial for healthy development (Bronfenbrenner & Evans, 2000). Structure, organisation, predictability, and lack of chaos in a household are reflected in the use of daily routines, which are in turn associated with improved outcomes (Evans et al., 2005).

Routines are therefore a component or a reflection of parental regulation, structure and lack of chaos in a household. Previous research has found the presence of family routines to be associated with improved child outcomes, including shorter bouts of respiratory infections (Boyce et al., 1977), social competence (Keltner, 1990), and improved health (Denham, 2003). Households which engage in daily routines promote the well-being of all members, and are invested in the maintenance of health over time (Fiese, 2007): a review by Fiese et al. (2002) concluded that family routines are related to individual well-being, with preschool children being healthier when there are predictable routines in the family.

This study expands on literature demonstrating a positive role of parental regulation and household schedules and routines in the well-being, health and development of individuals, including preschool children, by demonstrating a positive association of routine-led behaviours with sleep duration and a negative association with obesity-promoting behaviours. It also expands on studies documenting an association of parenting behaviours regarding sleep and bedtime with children's sleep, and of parenting styles with children's food intake patterns and obesity risk (see Chapter 3).

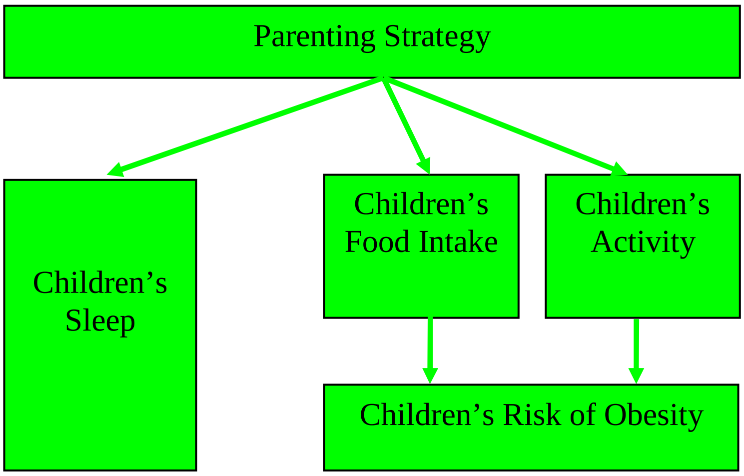
Summary: Role of Parenting in the Childhood Short Sleep-Obesity Link

Routine-led parenting behaviours for each domain (sleep, diet and activity) were correlated together and with longer sleep, obesity-protecting food intake and TV viewing patterns, and lower body composition SD scores in children. Contrastingly, routine-free parenting behaviours were correlated together, and with shorter sleep, obesity-promoting food intake and TV viewing habits, and greater body composition SD scores in children. Therefore, parenting strategy may explain some of the association between children's short sleep and risk of obesity. There was a cumulative effect of routine-led parenting behaviours, such that an increase in the number of routine-led behaviours was positively associated with an increase in sleep duration, a decrease in obesity-promoting diet and activity habits, and a decrease in central fat in children.

This section has addressed primary aim two, and has suggested that parenting may mediate the short sleep-obesity relationship in young children. Based on the results presented in this chapter, the literature reviewed in Chapters 2 and 3, and building upon Models A and D (Chapters 6 and 7), I have formulated Model E, as shown in Figure 8.12. (Note that due to the exploratory and cross-sectional design, associations and direction of causality cannot be determined.) This will be expanded on in the remainder of this chapter, and will be interpreted using an evolutionary perspective in Chapter 9.

Figure 8.12: Model E

Parenting strategy confounds the childhood short sleep-obesity link, by influencing children's sleep, food intake and activities (compared to routine-led parenting, routine-free parenting is associated with children's shorter sleep and greater risk of obesity, via obesity-promoting food intake and activities).



Variation in Parenting Strategies

This section of the chapter will explore causes and correlates of the different parenting strategies which are hypothesised to contribute to the childhood sleep-obesity link. Specifically, this section will a) describe ethnic and SES variation in the parenting strategies identified, b) explore explanations for SES variation in parenting strategies, and c) discuss parenting culture.

Ethnic Variation in Parenting Strategy

The proportion of BME children in this sample (13%) was small compared to white British children, preventing statistical comparisons in parenting strategies for sleep and activities, and there was no significant difference in parenting strategy for diet. However, there were differences in frequencies of parenting strategies with ethnicity which could be explored in further studies (see Table 8.15).

Table 8.15: Frequencies of Routine-Led Parenting Strategies with Ethnicity

Parenting Strategy	White British (n=95)	BME (n=14)
Parenting Strategy for Sleep (% routine-led)	78	57
Parenting Strategy for Diet (% routine-led)	61	39
Parenting Strategy for Activities (% routine-led)	43	64

White British families were more likely than BME families to be routine-led for sleep and diet, but this was reversed for activities. This pattern may reflect variation in attitudes towards activities, with white British parents being less regulatory regarding activities compared to sleep and diet, and BME families being more regulatory of activities. Alternatively, this may be an artefact of the small sample of BME families. Additionally, significantly more BME children lived in deprived areas compared to affluent areas, meaning that ethnic variation in parenting strategy may be confounded by SES. Further research is needed with greater numbers of non-white British families, and with specific ethnic groups (rather than a combined BME group), in order to examine ethnic variation in parenting styles, and associated variation in children's sleep and health. Associations of parenting strategies with ethnicity may help to explain ethnic disparities in sleep and obesity.

SES Variation in Parenting Strategy

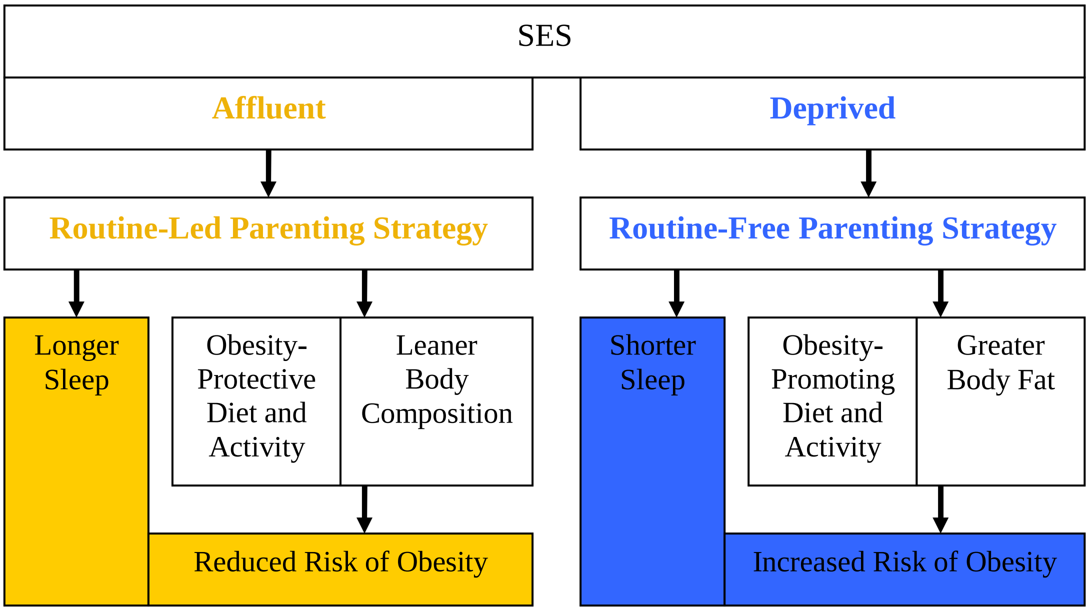
SES was significantly associated with parenting strategies for sleep, diet and activities: for each domain, routine-led parenting was more frequent in affluent areas, whilst routine-free parenting was more frequent in deprived areas (see Table 8.16).

Table 8.16: Frequencies of Routine-Led Parenting Strategies with SES

Parenting Strategy	Affluent (n=49)	Deprived (n=60)
Parenting Strategy for Sleep (% routine-led)	88	66
Parenting Strategy for Diet (% routine-led)	80	41
Parenting Strategy for Activities (% routine-led)	60	31

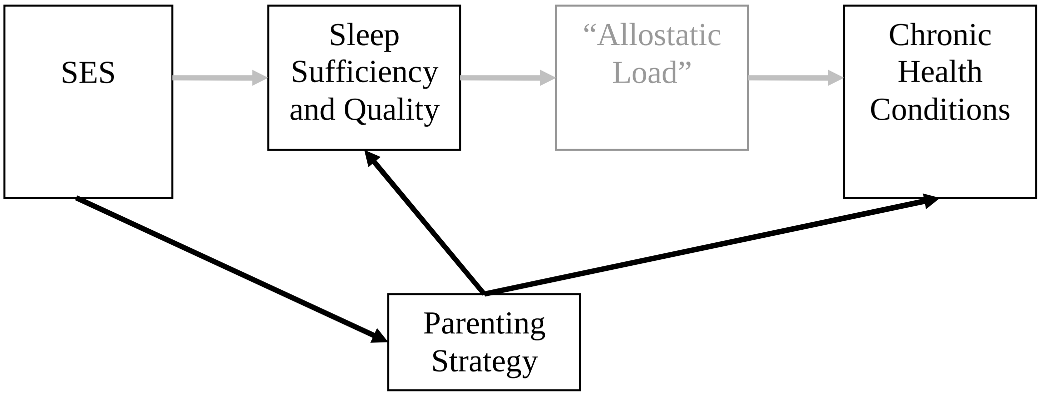
Since parenting strategy was associated with children's sleep and risk of obesity (above), this suggests a pathway through which parenting strategy may mediate the observed association of SES with children's sleep, food intake and TV viewing habits (see Chapters 6 and 7) (see Figure 8.13).

Figure 8.13: Possible Mediating Role of Parenting Strategy in the Associations of SES with Children's Sleep and Obesity Risk



The association of parenting strategy with SES expands on Bornstein et al.'s (2003) suggestion that the influence of SES on parenting beliefs and behaviours can cause an affect of parenting on child development. It also builds on Van Cauter & Spiegel's (1999) hypothesis that sleep mediates the relationship between SES and health (see Chapter 3), by suggesting that SES variation in both children's sleep and health may be explained by parenting strategy (see Figure 8.14).

Figure 8.14: Possible Mediating Effect of Parenting Strategy in the Association of SES with Children's Sleep and Health



Explanations for SES Variation in Parenting Strategy

Little is known about which specific features of SES influence which specific aspects of parenting (Bornstein et al., 2003). There are a number of components of SES which could explain the observed variation in parenting strategies in this sample, including household income and crowding, parental education and employment, and family composition, which varied between the deprived and affluent groups (see Chapter 5).

Maternal care is dependent on the amount and quality of economic resources; hence low SES and associated limited budget and resources can alter parenting behaviours (Wilson et al., 1995). The reduced household income and number of rooms per person in the house for families in deprived compared to affluent areas in this sample may therefore have affected parents' ability to maintain routine-led strategies. Sleep environment, food availability and activity options may be limited with lower income, which would impact on parents' behaviours and practices. For example, lack of space may have prevented children from sleeping in their own room, making sharing with parents or falling asleep on the sofa at night more likely; and lack of space may have prevented children from eating meals at a kitchen or dining room table.

There was variation in education level with SES. Parents in deprived areas were less well educated, which may have influenced their knowledge of healthy children's sleep, diets and lifestyles, and their parenting behaviours. In a review of SES and parenting, Bornstein et al. (2003) found that maternal education was the most robust individual socio-demographic predictor of mothers' parenting behaviours. In African American families, direct relationships of maternal education with competence and skill at parenting (Wilson et al., 1995) and child-centred parenting behaviours (Bluestone & Tamis-LeMonda, 1999) have been observed. Regarding parenting behaviours for sleep, Hale et al. (2009) reported low maternal education to be associated with decreased use of regular bedtimes and routines in 3-year-old American children, in particular interactive bedtime routines.

Maternal care is influenced by support from other adult household members, who can provide help with childcare and household duties, thereby increasing maternal parenting and child-rearing behaviours (Wilson et al., 1995). Hence being in a single parent household (which was more frequent in deprived areas) may have limited parents' ability to maintain routine-led strategies, whilst support from other parents (which was more common for affluent families) may have rendered routine-led behaviours more likely. Consistent with this hypothesis, Hale et al.'s (2009) study found that single-mother families were less likely to engage in regular bedtime routines compared to those with a social or biological father present. There was no variation in number of siblings between children in affluent and deprived areas, suggesting that competing demands from siblings did not influence SES variation in parenting behaviours in this sample.

Employment rates were greater for parents living in affluent compared to deprived areas. The demands of work schedules could restrict efforts to maintain regularity and routines; alternatively, the presence of work schedules may provide structure and schedules, thereby being an optimal environment for routine-led behaviours. Future research could examine associations of parental employment with parenting behaviours; in particular, differentiating between standard and nonstandard work schedules, since research has demonstrated negative effects for children of nonstandard maternal schedules in particular (Joshi & Bogen, 2007).

Mean maternal age was greater for families in affluent compared to deprived areas in this sample, hence possible age-related variation in parenting strategies may explain some of the variation in parenting strategies with SES. Ragozin et al. (1982) found age-related differences in parenting, with mothers' age being significantly positively related to time commitment to parenting and more optimal parenting behaviour. Perhaps younger mothers in this study (in deprived areas) were more likely to adopt routine-free strategies, and older mothers (in affluent areas) were more likely to adopt routine-led strategies, due to differential time and effort dedicated to parenting.

Further research should investigate variation in parenting strategies with specifically household crowding and income, family composition, parental education, employment, and maternal age. Examination of the determinants of parenting for both affluent and deprived SES groups could aid understanding of the factors that contribute to different parenting strategies and associated children's health.

Parenting Culture

Although aspects of deprived households such as low income, household crowding and lack of social support may limit parents' ability to maintain routine-led strategies, parents who described routine-free behaviours in this sample did not identify barriers to other, more desirable strategies: rather, they intended to be routine-free. There was variation in expectations between parents employing routine-led versus routine-free strategies, with each believing their approach to be preferable, which reflects their different 'parenting cultures'.

Cultural variation in parenting strategies, and its association with parenting behaviours and child development, has previously been reported. Super et al. (1996) described how Dutch parenting is organised around "the three Rs" (translated as rest, regularity and cleanliness), and is fundamentally different to American parenting. The authors hypothesised that these cultural differences were expressed in parents' daily caretaking behaviours, which may have developmental consequences for children (specifically sleep duration, which was longer for Dutch compared to American children).

The study of cultural issues impacting on children's development, including sleep, is a relatively new field in paediatrics (Owens, 2004). Whilst cross-country comparisons of parenting and children's sleep culture (such as Super et al., 1996) are scarce, comparisons of cultural issues associated with parenting and sleep within one country or by one discipline are even more so (Jenni & O'Connor, 2005). This study suggests that diverse parenting cultures exist within one geographic area, and systematic study of parenting and the issues impacting on parenting strategies is needed. Although parenting culture and the sociology and psychology of parenting are not the focus of this study, some key areas are outlined below which require further study.

a) Parenting Role

Between routine-led and routine-free parents there was variation in consideration of what the parental role entails. Parents who were routine-led believed that their role as parents required them to regulate their children:

"I [mum] think it's important to have rules, so children don't rule the roost." (ID 97)

"Children need restrictions to follow when they're growing up. So routine is important… Children can't argue with parents or make their own decisions. Parents control children, not the other way around." (ID 36)

Routine-led parents believed that regulation and routine were integral to the optimal development of children:

"Children are 'you'. Parents mould children into what they are, with routines and things." (ID 68)

Contrastingly, routine-free parents did not think that they were required to regulate their children's sleep, food intake or activities, and they considered a hands-off approach to parenting to be suitable:

"It's nothing to do with the parenting, if a child doesn't want to sleep, then it won't sleep." (ID 44)

Others further believed that parents should allow children to dictate the household, and actively promoted child self-governance and governance of their parents:

"Parents owe their life to their children; you should do things around them; that's why you've had children." (ID 54)

b) Household Structure versus Chaos

The use or lack of routines in parenting reflected the level of structure versus chaos in households. In chaotic (routine-free, mainly deprived) households, where routines, consistency and regulation were not part of daily life for parents, then they did not approach parenting this way. Contrastingly, routine-led parents found their approach to parenting to be a natural and integral component of an overall structured and regulated household:

"I [mum] have 6 children but our house is really quiet and really calm because everyone has enough sleep and they have little routines and they all have their place and it all fits together like a little jigsaw." (ID 91)

Hence specific routine-led behaviours (such as setting regular bedtimes, limiting children's access to food, restricting TV) are part of a wider family context where structure and routine are the norm. Routine-free behaviours reflect a wider context of chaos and lack of structure in the household. This is confounded by SES, since lower SES parents (more frequently routine-free) provide generally more chaotic, disorganised and unstructured environments than do higher SES parents (more frequently routine-led) (Bornstein et al., 2003).

c) Expectations for Child Regulation

As the above discussion demonstrates, routine-led parents expected their children's sleep, diet and activities to be consistent and regulated, and expected to take a role in achieving this. Routine-free parents did not expect regulation and consistency in their children's lifestyle, instead enabling children to be self-governing, particularly to sleep when and where they wanted, eat what they wanted, and undertake what activities they wanted.

Milan et al. (2007) similarly described cultural variation in parental expectations and values regarding child regulation, and the impact of this variation on children's lifestyles. They proposed that where child regulation is a desirable trait, routines and consistency are maintained to enable children to become well regulated; where being well-regulated is less of a priority, routines and consistency do not play a prominent role in lifestyles.

Some routine-led parents expected children to become independent in their regulation, particularly regulation of sleep (see Chapters 6 and 7). Expectations for child independence in sleep and sleep regulation have previously been described in Western societies, where parents commonly encourage children to sleep alone and use bedtime routines to facilitate independent sleep (Morelli et al., 1992). In Germany, parental expectations for young children to initiate and maintain sleep without their presence reflect parents' desires to raise children who are self-reliant (Valetin, 2005). Alternatively, where regulation and independence are not prioritised, bedtime and sleep routines are not as prominent; for example, Italian children engage in adult activities and fall asleep in the evening when they are tired rather than at scheduled times, since participation in family events is prioritised over regulation of sleep (Ottaviano et al., 1996). Thus children's sleep patterns and their regulation respond to wider cultural values, including the value placed on independence and self-regulation, and idealized family structures and behaviours (Jenni & O'Connor, 2005).

d) "Inheritance" of Strategies

Parenting behaviours and strategies for parents in this sample were learned from family members (particularly parents) and sometimes friends. Whether they were routine-led or routine-free, parents commonly described that they did what was familiar to them based upon their own experiences of growing up:

> *"I'm [mum] stricter…because that's the way my parents were with me."* (ID 39)

This is consistent with the intergenerational transmission of parenting, whereby an earlier generation psychologically influences parenting attitudes and behaviours of future generations (Van Ljzendoorn, 1992). Evidence suggests that some transmission of parenting behaviours may also be genetic; for example, Perusse et al. (1994) studied adult twins, and reported heritability in parenting behaviours (specifically care and overprotection).

Whilst there was transmission of routines, consistency and limit-setting in routine-led parents, these were not transmitted in routine-free families. A shift in parenting culture, from routine-led to routine-free, was identified by one mother, who considered her routine-led approach to parenting to be out of fashion:

> *"I [mum] think I'm old-fashioned in having a routine. I think it is old-fashioned now to have a routine. I see children who don't have set meal times, bedtimes, watch TV to go to bed, fall asleep on the sofa."* (ID 96)

The positive association of routine-led compared to routine-free parenting with children's sleep and health suggests that these are not equally viable parenting strategies. Perhaps a routine-led approach to parenting, and transmission of routine-led behaviours, has been lost in routine-free families, resulting in a shift away from routines and regulation of children by parents, towards lack of routines, inconsistency and child-governance. The conditions under which parenting is not transmitted across generations are poorly understood (Belsky et al., 2009). The suggested shift in parenting culture from routine-led to routine-free has occurred in deprived areas more than affluent areas: perhaps this is due to the increased chaos and stress experienced by families in lower SES groups, and the lack of support available to lower SES parents (Bornstein et al., 2003). Shifts in parenting strategy may be partly a result of the advent of electronics and particularly the TV in recent decades, which has altered the social context of the family, including parent-child relationships (Bumpass, 1990).

Study of the historical sociology of parenting could expand on some of these highlighted issues, furthering understanding of variation in parenting strategies and the impact on children's sleep, risk of obesity, and their association. In particular, further research could examine psychological aspects of parenting and historical shifts in parenting strategies and their association with children's health; and impact of the wider contributors to parenting strategy (such as technological innovation).

Summary: Variation in Parenting Strategies

Parents in affluent areas were significantly more likely to be routine-led, whilst routine-free parenting was more prevalent in deprived areas. Variation in parenting strategy may confound the relationship of SES with children's sleep and health. Family composition, resources, parental education and maternal age may explain some of the SES variation in parenting. Individual parenting behaviours are part of a wider context of 'parenting culture' which differs between routine-led and routine-free parents; this includes consideration of what the parenting role requires, household structure versus chaos, and expectations for child regulation. Intergenerational transmission of routines, regulation and consistency in routine-led but not routine-free families may contribute to variation in parenting strategies.

Further examination of the contributors and determinants of different parenting strategies could improve understanding of variation in children's health, and the influence of parenting. Research could examine variation in parenting attitudes and practices across different ethnic groups and with SES factors (including household income and crowding, family composition, parental education, employment and age);

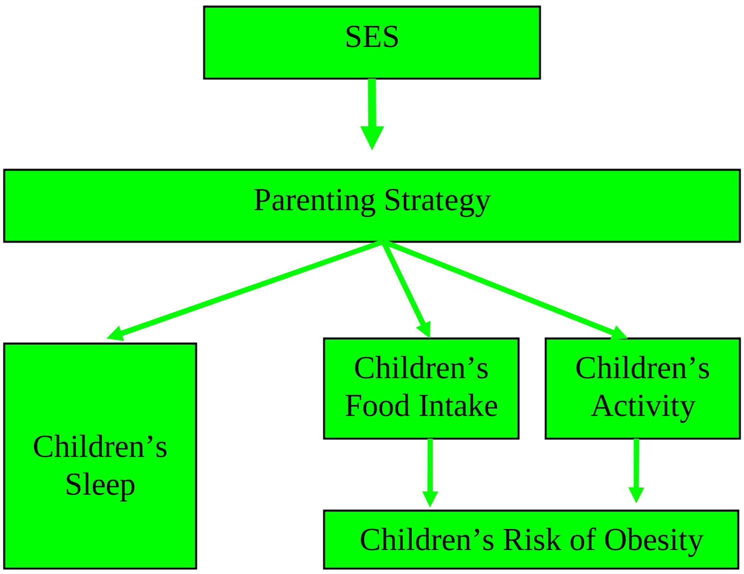
the psychology and historical sociology of parenting; and the intergenerational and cultural transmission of diverse parenting strategies.

Based on the results presented in this thesis, in addition to the literature reviewed in Chapters 2 and 3, I have formulated the Parental Confounding Hypothesis, as shown in Figure 8.15.

Figure 8.15: Parental Confounding Hypothesis

Parenting strategy confounds the sleep-obesity link in young children, by influencing children's sleep, food intake and activities (compared to routine-led parenting, routine-free parenting is associated with children's shorter sleep and increased risk of obesity, via obesity-promoting food intake and activities).

Parenting mediates the association between SES and children's health (higher SES parents are more likely to be routine-led, and lower SES parents are more likely to be routine-free; children in lower SES groups are at greater risk for short sleep and obesity compared to those in higher SES groups).



Chapter 8 Summary: Mechanisms Linking Children's Short Sleep and Obesity

This chapter addressed primary aim one by examining possible mechanisms linking children's short sleep with risk of obesity, via diet and activity behaviours. Potential mediating and confounding pathways identified, which require further research, are appetite and obesity-promoting food intake, daily food distribution (particularly timing of the evening meal), and particularly evening TV viewing. Based on the results presented in this thesis and the literature reviewed in Chapters 2 and 3, I generated the Behavioural Mechanisms Hypothesis.

The chapter then addressed primary aim two, and presented how parenting strategy may confound the link between children's sleep and risk of obesity. Routine-led parenting strategies were positively associated with children's sleep duration, obesity-protective dietary and TV viewing patterns, and lower body composition SD scores; routine-free parenting strategies were associated with shorter sleep duration, obesity-promoting dietary and TV viewing patterns, and greater central fat in children. Routine-led parenting was more prevalent in affluent areas, and routine-free parenting was more prevalent in deprived areas. Based on the results presented in this thesis and the literature reviewed in Chapters 2 and 3, I generated the Parental Confounding Hypothesis.

Primary aim three was addressed throughout the chapter. I suggested that individual parenting behaviours are part of a wider context of 'parenting culture' which differs between routine-led and routine-free parents, including expectations for their children's regulation and their role as parents.

The following chapter will draw together and discuss the results and hypotheses presented in Chapters 6-8, and will apply an evolutionary perspective. It will discuss the wider implications of the study findings, its effectiveness at meeting the research aims, and the relevance for future research and policy.

Chapter 9: Summary of Findings, an Evolutionary Perspective, and Concluding Thoughts

This chapter will summarise and discuss the main study findings. The hypotheses proposed will be interpreted using an evolutionary medicine perspective, since this approach may help to explain the existence of the proposed mechanisms linking short sleep with obesity. Limitations in the study will be outlined, and conclusions will be drawn.

Summary of Research Findings

This exploratory study examined behavioural mechanisms posited to explain the link between short sleep and obesity in preschool children (in particular mediation by obesity-promoting behaviours, and confounding by parenting). It considered variation in sleep and behaviour in relation to ethnicity and SES, and wider social and cultural attitudes and values.

There were some associations of children's sleep with dietary and activity behaviours, which may mediate the short sleep-obesity link, in particular appetite and obesity-promoting food intake. Behavioural factors which were proposed to be associated with both short sleep and obesity, and to confound their relationship, were consumption of carbonated drinks, distribution of food through the day (particularly evening food intake), and TV viewing in the evening.

Regarding parenting, for each domain (sleep, diet and activity), two main parenting strategies were identified, which were termed routine-led (based on regulation and routine) and routine-free (less structured, and based on child-governance). These parenting strategies were associated with children's outcomes (sleep, food intake and

TV viewing), suggesting a potential confounding role of parenting in the short sleep-obesity link. Parenting strategy varied with SES (routine-led parenting was associated with higher SES, and routine-free parenting was associated with lower SES), indicating a mediating role of parenting in the relationship of SES with children's health.

Based on these study findings and the literature reviewed, I have proposed two hypotheses: the Behavioural Mechanisms Hypothesis and the Parental Confounding Hypothesis (shown in Figures 8.6 and 8.15).

Figure 8.6: Behavioural Mechanisms Hypothesis:

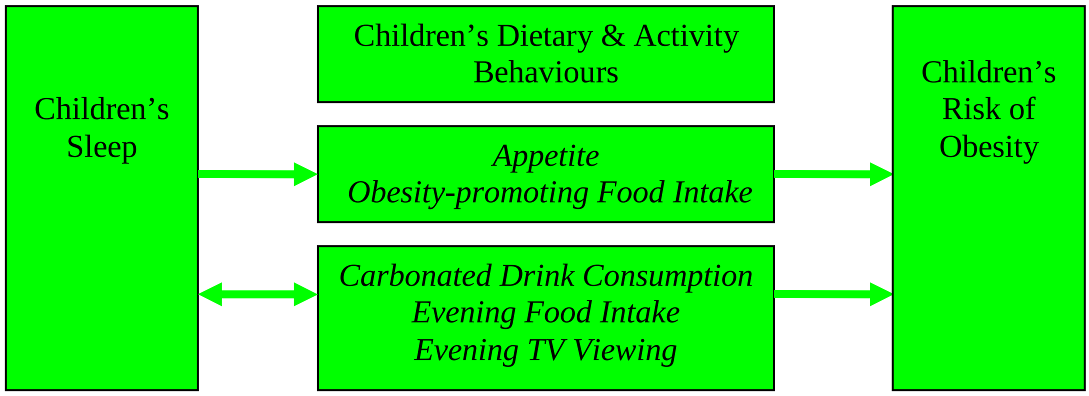
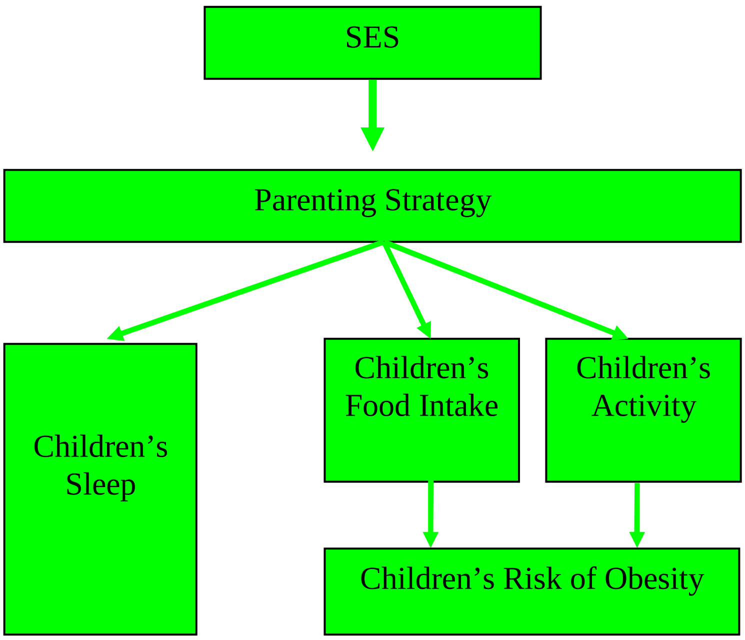


Figure 8.15: Parental Confounding Hypothesis:



These hypotheses directly answer the primary aims of this study. In analysing the data and formulating these hypotheses, the secondary aims were addressed. How the aims were addressed, and the main findings, are summarised in Table 9.1.

Table 9.1: Research Aims, How they were Addressed and Summary of Main Findings

Aim		How the Aim was Addressed & Main Findings
Primary Aim One	*Explore potential behavioural mechanisms linking short sleep and obesity in preschool children, particularly obesity-promoting dietary and activity behaviours*	Behavioural Mechanisms Hypothesis: Dietary and activity behaviours are proposed to mediate and confound the short sleep-obesity link.
Primary Aim Two	*Explore the potential role of parenting in the childhood sleep-obesity link*	Parental Confounding Hypothesis: Parenting strategy is proposed to confound the sleep-obesity relationship.
Primary Aim Three	*Consider ethnicity and SES, and the wider impact of social and cultural attitudes and values in relation to the childhood sleep-obesity link*	Parental Confounding Hypothesis: Parenting strategy and children's sleep and obesity risk vary with SES. Wider social attitudes and values influence parenting attitudes, practices and strategies.
Secondary Aim One	*Improve on sleep measures used to examine the sleep-obesity relationship, particularly to assess sleep over a longer period (rather than a single night or parent-report of a typical night); assess variability in sleep duration (including week/weekend day and seasonal variation); and include naps in addition to nighttime sleep*	Sleep duration over 5 nights was used in analyses. Sleep duration was measured using an actigraphy-validated method of parent-report. Significant differences were found between week and weekend sleep-wake patterns; this was accounted for by using weighted means. There was no significant variation in children's behaviours according to daylength or timing of nursery session. Nighttime, daytime and total daily sleep durations were examined separately; total daily sleep duration only was associated with body composition.
Secondary Aim Two	*Examine waist circumference and skinfold thickness in addition to BMI, to add to the growing body of literature examining relationships between sleep and more direct measures of central adiposity*	BMI, waist circumference and subscapular and triceps skinfold thicknesses were measured; the most direct measure of central adiposity only (subscapular skinfold thickness) was associated with sleep duration.
Secondary Aim Three	*Conduct a detailed investigation into sleep in a sample of preschool children, to add to the limited literature regarding children's sleep*	A detailed description of sleep patterns over 4 days/5 nights was obtained in 91 3-year-old children. Total daily sleep was shorter in comparison to reference data, perhaps due to relatively short and infrequent napping in the absence of longer nighttime sleep.

Daytime, nighttime and combined total daily sleep durations were analysed individually; the results suggest that napping can compensate for short nighttime sleep, and that the total amount of sleep across the day, rather than its composition (consolidated nighttime or combined nighttime and daytime sleep), is associated with body composition. Perhaps napping is beneficial in ameliorating the negative effects of short nighttime sleep. Despite the potential benefits, napping was negatively perceived by many parents in this sample, and was generally associated with lack of limit-setting and a laissez-faire attitude in parents. Consequently, napping was infrequent and short in this sample, and total daily sleep duration was short, compared to reference data.

Subscapular skinfold thickness was more consistently associated with variables in this study than was BMI, waist circumference and triceps skinfold thickness. For example, subscapular skinfold thickness only was associated with total daily sleep duration, and with number of routine-led parenting behaviours. Subscapular skinfold thickness was the most direct measure of central fat used in this study, and so this pattern of results suggests the importance of central fat in particular, which is significant since central fat is more closely correlated with health outcomes than is general fat.

In accordance with the study design, a non-random sampling strategy was used. Whilst this was appropriate for this exploratory study, and enabled the generation of hypotheses, it restricts generalisability of the trends identified in this study to the general population. The study was conducted in the context of a socio-demographically diverse area of North-East England, experiencing a Westernised, obesogenic environment and a relatively high proportion of low SES families. In order for the findings and hypotheses to be considered more generalisable to the whole population, future research should test the hypotheses in larger and appropriately sampled nationally-representative samples, in different populations, using more rigorous statistical techniques.

Study Findings: An Evolutionary Perspective

As described in Chapters 1 and 3, evolutionary medicine is an insightful perspective from which to approach health research, which has been applied to the study of obesity, and may be a novel and effective way in which to approach the sleep-obesity link. This section of the chapter will interpret the hypotheses proposed in this study using an evolutionary medicine perspective. The context of the research is important: this study took place in North-East England, in a Westernised population experiencing an obesogenic environment (an environment which promotes higher energy consumption than energy expenditure).

Behavioural Mechanisms Hypothesis: An Evolutionary Perspective

The Behavioural Mechanisms Hypothesis proposes that short sleep and obesity are related via obesity-promoting dietary and activity behaviours; these behaviours are either mediators or confounders of the sleep-obesity link.

Specific mediating factors which are proposed in this hypothesis are appetite and obesity-promoting food intake. Evolutionary models can explain why short sleep alters appetite and food intake. From an evolutionary perspective, it is adaptive for risky conditions (threat from predators, restricted food intake) to result in both sleep loss and increased appetite, in order to maximise activity potential and energy intake. Thus it is logical that short sleep should co-occur with increased motivation to eat, including increased appetite and food intake. Indeed, in rodent models, periods of starvation resulted in increased vigilance and sleep loss, presumably to increase foraging time and food finding (Penev, 2007, see Chapter 2). This linking of short sleep with appetite and food intake is now maladaptive in contemporary Western conditions, in which short sleep is able to occur in conditions of plentiful food rather than food restriction. Thus in industrialised societies, short sleep, via resulting increase in appetite and food intake, can lead to weight gain and obesity.

A proposed confounding factor in the Behavioural Mechanisms Hypothesis is evening TV viewing. In evolutionary terms, TV viewing in the evening is discordant with conditions optimal for children’s sleep and healthy weight. Sleep evolved to occur in dark periods, with activity occurring in daylight periods. Artificial light has disrupted these natural sleep regulatory mechanisms. Light from the TV is particularly disruptive: melatonin (a sleep-promoting hormone) is suppressed by blue light especially, which is emitted by TV screens (see Chapter 3). Hence evening light and TV viewing in particular is discordant with sleep biology, and leads to sleep disruption.

Furthermore, being sedentary is a novel condition in evolutionary terms; hence TV viewing, as a sedentary activity, is discordant with optimal conditions for children's health and development; particularly when this is coupled with abundant food availability. It is also evolutionarily novel and discordant for short sleep and sedentary activity to co-occur: in the rodent model mentioned above, sleep loss resulted in increased vigilance and presumably foraging, meaning that short sleep is adapted to result in increased, rather than decreased, activity levels.

In sum, dietary and activity behaviours which are proposed to mediate or confound the sleep-obesity relationship according to the Behavioural Mechanisms Hypothesis are discordant with conditions for optimal health and development in children. Behaviours which were designed to be associated with short sleep, in order to increase health and survival, are now discordant with modern ecological conditions. Children's biology is adapted to conditions of increased physical activity and restricted food availability; matching of sleep patterns to light-dark cycles; and coupling of sleep with appetite, to drive food intake in conditions of risk. In modern industrialised societies, with increased sedentary activity, abundance of obesity-promoting foods, and artificial light and electronics, it is now maladaptive for these behaviours to be associated with sleep. Hence behaviours associated with short sleep, instead of optimising survival potential, now contribute to weight gain and obesity.

Parental Confounding Hypothesis: An Evolutionary Perspective

The Parental Confounding Hypothesis proposes that parenting strategy impacts on both children's sleep and risk of obesity, and thereby confounds the short sleep-obesity relationship. Children of routine-led parents had longer sleep, relatively obesity-protective dietary and activity behaviours, and lower body composition SD scores;

whist children of routine-free parents had shorter sleep, relatively obesity-promoting dietary and activity behaviours, and greater body composition SD scores. This implies that parenting and the types of strategies undertaken by parents in the care of their children are important for children's health and development, and that routine-led compared to routine-free parenting is more optimal for children's health. This influence of parenting can be understood by applying the Discordance Hypothesis (see Chapter 3).

Parenting Strategy and Children's Sleep: An Evolutionary Perspective

Chapter 3 described the change in sleep patterning through evolution, and compared sleep in contemporary Western societies to ancestral humans and non-industrialised societies. This model can explain Hypothesis A which was proposed at the end of Chapter 6: that children's sleep is influenced by parenting strategy; specifically, children of routine-led parents have longer sleep compared to those of routine-free parents.

The uncoupling of sleep from ecological and environmental cues through evolution, and the resultant change in sleep patterns, demonstrates a loss of regulation of sleep. Sleep for ancestral humans, as in non-industrialised societies today, was regulated by environmental cues and light-dark cycles. Coupled with the cultural acceptability and expectation of unbounded sleep throughout the day, this led to adequate sleep opportunity throughout the day and night (Worthman & Melby, 2002).

In industrialised societies, sleep is no longer restricted and regulated in this way. Environmental cues for sleep-activity patterns have been uncoupled from and no longer regulate sleep patterns, whilst expectations for daily activity have increased, resulting in limitations in sleep opportunity. If left unchecked, the result is sleep loss.

In order to prevent sleep loss from occurring, and to ensure adequate sleep in this novel evolutionary environment, sleep must be regulated by some other mechanism; for preschool children, parents can perform this function. Sleep opportunities are bounded and restricted: parents who are able to regulate their children's sleep to be initiated at an appropriate time and maintained throughout the accepted nighttime period enable their children to fulfil their sleep potential in these restricted periods.

This is summarised in Figure 9.1, which explains the associations of routine-led and routine-free parenting with children's sleep. Strand A depicts ancestral conditions resulting in adequate sleep opportunity. In modern conditions, children whose parents are routine-free follow Strand B: sleep is un-regulated, and relatively short in duration. Children whose parents are routine-led follow Strand C: routine-led behaviours in this study were analogous with behaviours to maximise sleep efficiency and sleep potential in restricted, pre-defined periods. Adhering to regular and appropriately early bedtimes ensures that children can maximise their opportunity for sleep at night. By cueing children that the sleep period is about to start, regular and relaxing bedtime routines help to prepare children to fall asleep at the start of the sleep period thus minimising the sleep onset period. Consistently putting children to bed in a quiet environment alone and maintaining this sleep location throughout the night promotes efficient sleep and prevents the development of unsustainable sleep associations which could prevent children from sleeping efficiently on their own. Thus parents who regulate sleep and promote routines at bedtime enable their children to obtain sufficient sleep in industrialised conditions, by replacing environmental sleep regulation with their own regulation.

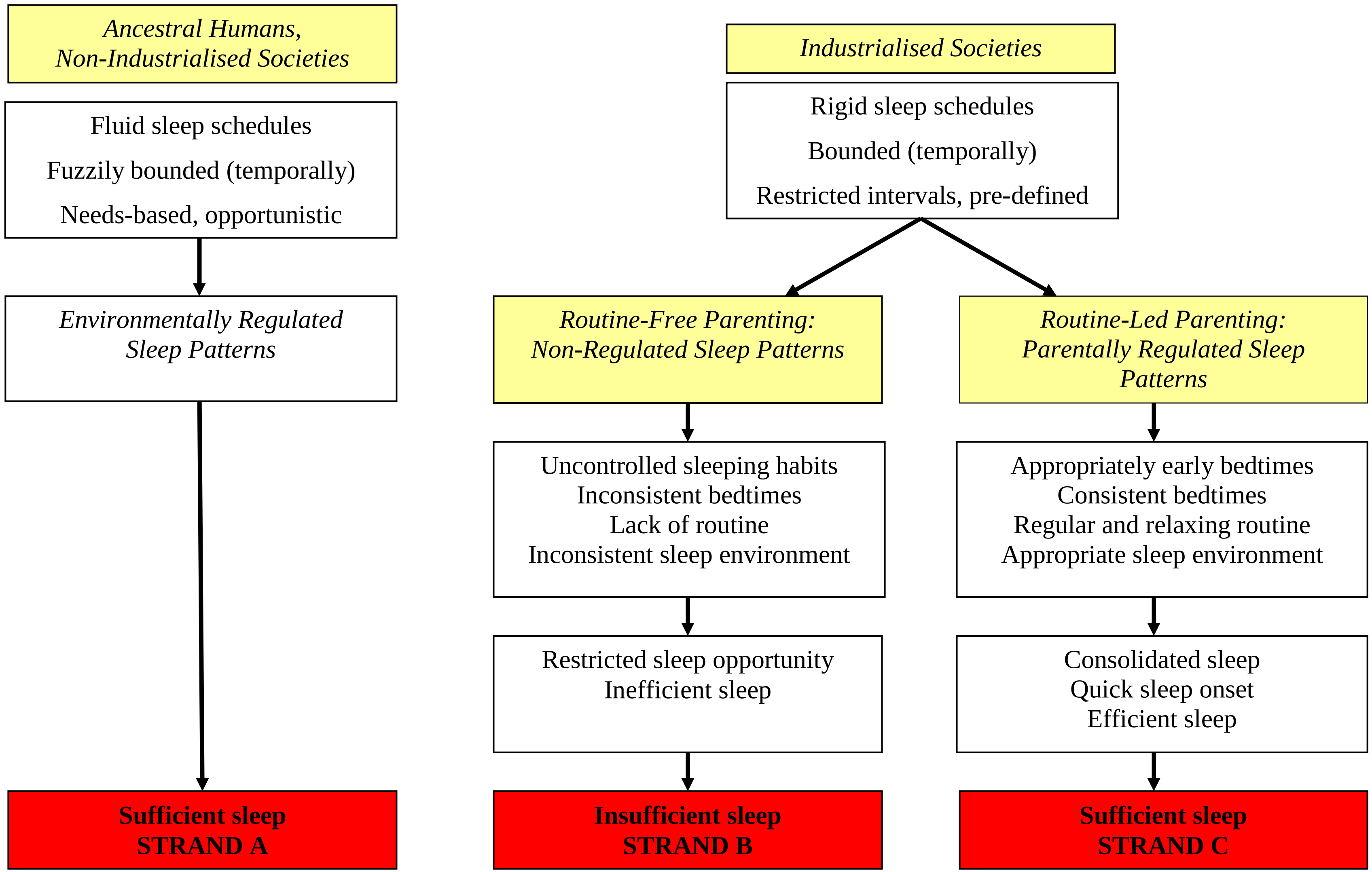
These different strands have significance for children's health. Children whose sleep is unregulated and insufficient (Strand B, routine-free parenting) have greater discordance between their biological sleep need and the restricted sleep which they are able to achieve under industrialised conditions. This leads to negative health consequences of short sleep. Contrastingly, children whose sleep is regulated and sufficient (Strand C, routine-led parenting) achieve sleep amounts which more closely match those of their physiological needs and expectations, based on adaptation to non-industrialised conditions and environmentally-regulated sleep patterns. Consequently, they are protected from sleep-related ill-health.

Figure 9.1 can answer the question posed by Jenni & O'Connor (2005) (outlined in Chapter 3), regarding the goodness of fit between children's biological sleep needs and their culturally normative bedtime practices:

> “*Are the cultural standards provided by our own society optimal for the development of our children*?” (p. 214)

I answer, on the basis of this thesis, that the sleep practices provided by routine-led parents enable optimal development for children, whilst the practices of routine-free parents do not enable optimal development for children. Children of routine-led parents have sleep patterns which suit their biological need, whereas children of routine-free parents have sleep patterns which do not match those optimal for their biological needs: this supports the suggestion by Fleming (2010) that sleep-related problems arise when children are made to sleep in ways which do not match their biological need.

Figure 9.1: A Model for the Regulation of Children's Sleep and Sleep Sufficiency



Parental Regulation of Sleep in Recent History

There is some documentation of change in general opinion and attitudes towards regulation of children's sleep through recent American history (see Stearns et al., 1996). In the nineteenth century, children's sleep was considered to be self-regulating, requiring no medical or parental attention. From the early twentieth century, there was increasing awareness of the importance of sleep for health promotion. An increase in the amount of sleep children required was claimed; parental responsibility for adequate children's sleep increased, and an impulse to impose regular schedules developed. Growing cultural desirability for independence and self-control in children contributed to heightened concern with the regulation of children's sleep in Western culture (Jenni & O'Connor, 2005). Regularisation was particularly visible in the 1920s and 1930s, when both child experts (such as psychologists) and popular media (such as family magazines) recommended rigid nighttime and nap sleep schedules for all children. Regularity was desirable for children themselves, and also attractive to parents, since it provided them predictability and more time to themselves. This was especially important with the increasing opportunities and demands for parents (particularly mothers) to socialise in the evening, and with the decline in live-in grandparents and maids. Later in the twentieth century, the rigidity in schedules relaxed so that there was flexibility according to individual sleep need and family preference; but the idea of some scheduling persisted (Stearns et al., 1996).

This study suggests that variation in parents' concerns with the regulation of children's sleep exists in the study population today, and is associated with the achievement of adequate sleep by children. Routine-free parents in Stockton-on-Tees adopt attitudes more in line with the nineteenth century American attitude of sleep requiring no parental regulation. The attitude of routine-led parents is more in line with the twentieth-century concern with regulation of children's sleep. Perhaps routine-free parents have experienced a reversal of general opinion away from the regulation of children's sleep, and back to the expectation that children's sleep is self-regulating and does not require parental attention. This supports the shift in parenting strategies and loss of transmission of routine-led parenting proposed in Chapter 8. Again, the historical sociology of parenting is not a focus of this study, and may be a worthy area for future research.

Parenting Strategy and Children's Risk of Obesity: Evolutionary Perspective

Chapter 3 described changes in diet and activity patterns through evolution, and compared diet and activity, and resulting obesity risk, in contemporary Western societies versus ancestral humans and non-industrialised societies. This model can explain Hypothesis D which was proposed at the end of Chapter 7: that parenting strategy impacts children's risk of obesity, via children's food intake and activities; specifically, children of routine-free parents are at a greater risk of obesity compared to children of routine-led parents.

For ancestral humans, and in non-industrialised societies today, environmental regulation, including the types and quantities of foods available in combination with relatively high physical activity demands, ensured that risk of obesity was low. In contemporary industrialised societies, diet and activity patterns have become uncoupled from physical environmental regulation; the increase in food availability, development of food preparation and storage methods, travel and technology, and the development of work and school schedules, have led to an undermining of environmental regulation on diet and activity. Children are able to be less physically active and more sedentary, in an environment in which food, including obesity-promoting food, is readily available. If left unregulated, the result of this change in food intake and energy expenditure is increased risk of weight gain and obesity.

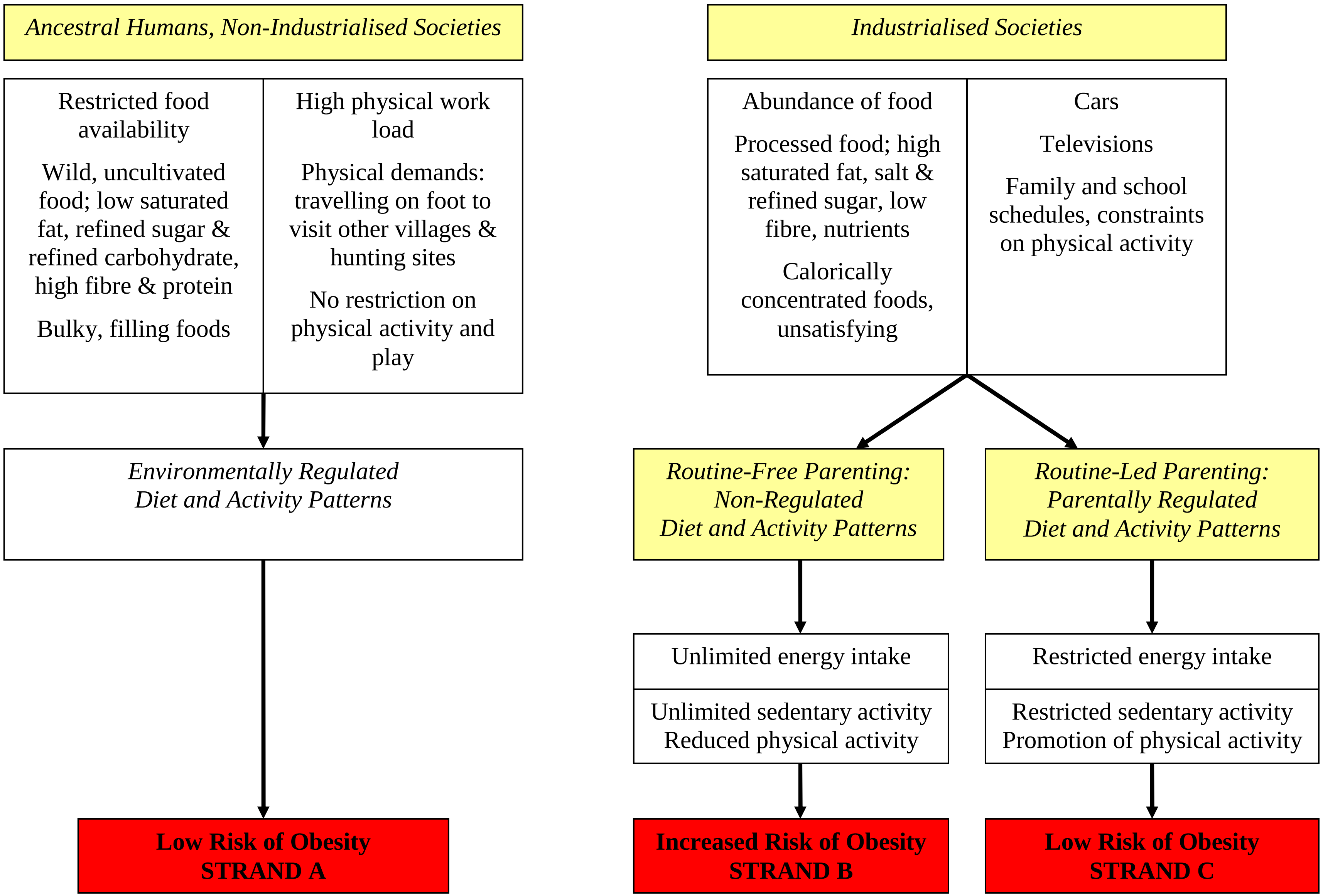
In order to prevent energy imbalance and increased risk of obesity in this novel evolutionary environment, diet and activity must be regulated by some other mechanism; for preschool children, parents can perform this function. Parents who regulate their children's diets and activity levels regulate the balance between energy intake and expenditure, enabling obesity risk to remain low.

This is summarised in Figure 9.2, which explains the associations of routine-led and routine-free parenting with children's risk of obesity. Ancestral conditions, resulting in low risk of obesity, are depicted in Strand A. Children whose parents are routine-free follow Strand B: their food intake and activity levels are unregulated, leading to an imbalance between energy intake and expenditure, and an increase in risk of obesity.

Children whose parents are routine-led follow Strand C: routine-led behaviours in this study were analogous with behaviours to regulate children's food intake and activity, and maintain an appropriate balance between energy intake and expenditure. By restricting certain foods (particularly foods high in fat, sugar and calories) and regulating mealtimes, parents are able to monitor and regulate their children's energy intake. Limiting TV viewing and promoting child-centred activities enable parents to regulate energy expenditure.

The discordance between children's biology and physiological expectations (based on an ancestral environment of high physical activity and limited food availability), and the food intake and activity levels which children experience in contemporary industrialised conditions, is reduced in children whose parents are routine-led compared to routine-free. Routine-led parenting mirrors or mimics the regulation which was previously performed by the environment, enabling children's risk of obesity to remain low.

Figure 9.2: A Model for the Regulation of Children's Diet and Activity Patterns, and Risk of Obesity



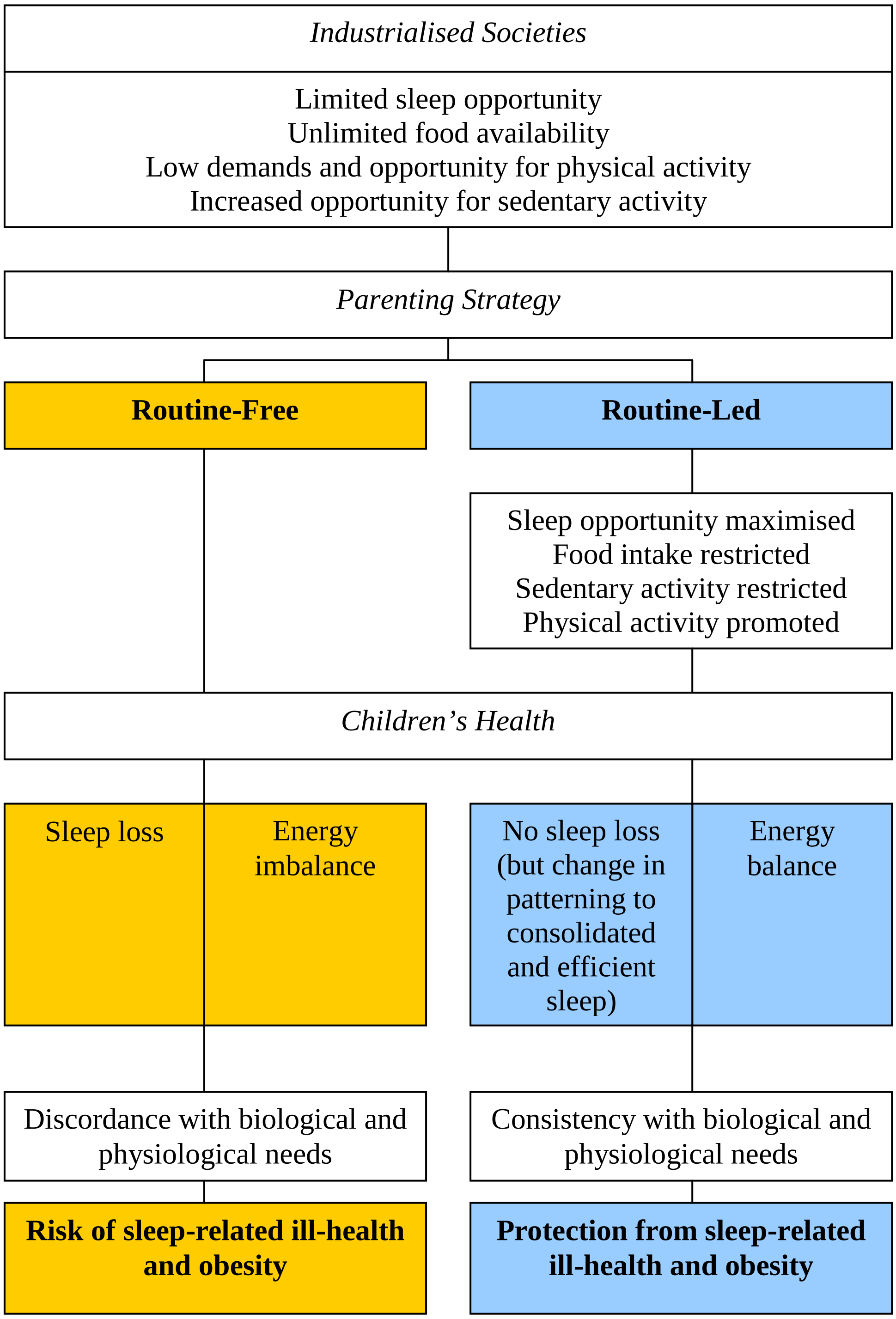
Discordance and the Role of Regulation

The models shown in Figures 9.1 and 9.2 propose that lack of regulation of children's sleep, diet and activity (industrialised societies: routine-free parents) results in sleep loss and energy imbalance (leading to increased risk of obesity). Regulation of children's sleep, diet and activity, either ecologically (ancestral humans and non-industrialised societies) or by parents (industrialised societies: routine-led parents) promotes adequate sleep and energy balance (reducing risk of obesity) in children.

Where ancestral conditions are mimicked (as in routine-led parenting), children's behaviours are brought in line with their biological needs. This is consistent with Eaton et al.'s (1988) "Palaeolithic Prescription", which describes ways in which to minimise discordance, bring diet and activity levels in line with biological needs and expectations, and thereby reduce risk of diseases of modern lifestyles. The current study extends Eaton et al.'s hypothesis to sleep, and suggests that by maximising sleep opportunity and efficiency, routine-led sleep patterns can be brought in line with biological needs. Whilst regulation enables adequate sleep to be achieved, this sleep is patterned differently to that of ancestral humans. For ancestral humans, sleep was segmented and fluid. Given the restricted sleep opportunities available in industrialised societies, consolidated, efficient sleep and maximisation of restricted nighttime sleep opportunities are required for adequate sleep to be achieved, which in turn requires routines and regulation (as in routine-led parenting).

I suggest that for preschool children, parents are able to limit discordance and take the role of the "Palaeolithic Prescription", by undertaking routine-led parenting strategies. Thus the degree of discordance between children's biological needs and their environment and experiences is the reason why parenting strategy is associated with both children's sleep and risk of obesity, and confounds their relationship (Parental Confounding Hypothesis). Routine-led parenting results in lesser discordance, and routine-free parenting results in greater discordance and conditions less optimal for children's health and development. This is depicted in Figure 9.3.

Figure 9.3: Impact of Parenting Strategy on the Discordance between Children's Biological Needs and their Environment, and Related Ill-Health



Thus I hypothesise that routines and regulation by parents are necessary components of healthy children's lifestyles in industrialised society. This builds upon the suggestion of Wake et al. (2007): in finding that low paternal control was associated with increased risk of obesity in preschool children, the authors proposed that warm, firm parenting may partly protect against overweight in the current obesogenic environment. The present study extends their hypothesis to children's sleep, and its association with obesity: routine-led parenting strategies are able to protect against sleep loss and obesity in the current industrialised environment.

The Parental Confounding Hypothesis proposes that parenting strategy mediates associations of SES with children's health, because parenting strategy varies with SES. The evolutionary model shown in Figure 9.3 cannot predict why lower SES parents are more likely to be routine-free, whilst higher SES parents are more likely to be routine-led; however, it suggests that conditions in higher SES families are less discordant with those optimal for children's health and development than are conditions in lower SES families.

Summary: Study Findings: An Evolutionary Perspective

Using an evolutionary medicine perspective, the Behavioural Mechanisms Hypothesis and Parental Confounding Hypothesis can be explained as the uncoupling of environmental regulatory mechanisms on children's sleep, diet and activities, and discordance between children's experiences and their biological needs. Children's health is adversely affected by their evolutionarily novel environment, in which sleep loss and obesity-promoting behaviours can co-occur. Routine-led parents minimise the discordance between children's biological needs and their experiences by regulating their sleep, diet and activity, resulting in adequate sleep and low risk of obesity. The increased discordance in children of routine-free parents results in short sleep and increased risk of obesity.

Study Limitations

This study was intended to identify trends and themes and to generate hypotheses for future research. There are a number of limitations inherent in the exploratory design. This design was most appropriate due to the lack of prior knowledge and preconceived hypotheses regarding the wider context of the sleep-obesity link; however, it prevents firm conclusions from being drawn, and limits confidence in the results. It is important to consider this and other limitations when interpreting the results.

Type I and II Errors and Statistical Power

Absence of specific prior hypotheses and power calculations means that there is possibility of Type I errors (whereby associations appear to be significant when they are in fact non-significant). Furthermore, the large number of statistical tests performed in this dataset is likely to have increased the risk of false positive associations. To minimise this risk, tests were performed only when a clear rationale was presented. No post-hoc power calculations were performed due to concerns regarding the validity of this approach for interpreting existing data (Hoenig & Heisey, 2001). However, the consistency of trends in the data raises confidence in the findings: for example, routine-led behaviours were consistently associated together, with more optimal health behaviours for children, and were associated with the affluent group; and routine-free parenting behaviours were consistently associated together, with more obesity-promoting and less optimal health behaviours for children, and with the deprived group; this consistency increases confidence in the Parental Confounding Hypothesis.

Additionally, qualitative data were able to support and explain the quantitative data, and the findings were underpinned by previous literature; this further increases confidence in the findings. Importantly, the aim of this exploratory study was to examine different aspects of the sleep-obesity link, identify trends, and propose hypotheses for future research: the study design, despite lack of power calculations, enabled this and was successful in meeting the research objectives.

The large sample size in this study (n=109) also increases confidence in the results and in the trends identified. Moreover, this relatively large sample for an exploratory study decreased the risk of Type II errors (whereby associations which are significant appear to be non-significant). However, the relatively small proportion of overweight and obese children in the sample (compared to national rates) may have prevented associations with body composition from being identified.

Methods

The methods selected were appropriate for the study design, and incorporated improvements in methods used in previous studies. In particular, the assessment of sleep over 4 days/5 nights enabled a more extended examination of children's sleep, including week and weekend days, rather than single estimates of sleep duration as used in previous studies into the sleep-obesity link. Additionally, daytime naps in addition to nighttime sleep were used in sleep duration analyses.

Despite the strengths of the method used to assess children's sleep duration, there are natural limitations in parent-report measures. Parent reports are naturally subjective rather than objective. Risk of parents overestimating sleep duration by reporting bedtime rather than sleep onset time was minimised by clearly asking parents to document both the times at which their children got into bed and went to sleep. Furthermore, the sleep section of the diaries was validated by actigraphy: parents were found to accurately report their children's sleep and wake times and daily nap durations in comparison with actigraphy, which increases confidence in the parent-report diaries. Using actigraphy for all participants would have enabled a more reliable estimate of sleep duration to be obtained; however, this was not possible with the resources available for the project, would have lowered participation rate (almost 50% of children whose parents consented to the actigraphy phase failed to comply for the full period), and was not necessary for the purposes of this exploratory study.

Regarding diet, more thorough examination of food eaten by children (for example weighing and measuring by parents, or validated food questionnaires) would have enabled a more detailed and accurate examination of nutritional composition of children's diets and the role of diet in the sleep-obesity association. This was not considered appropriate for this study, due to the added burden on participants, the increased time needed for data processing and analysis, and lack of preconceived hypotheses regarding dietary components in the sleep-obesity link. Consumption of drinks was particularly problematic in this study: some parents did not document any drinks in the diary at all, and many entries were ambiguous (such as 'orange juice') and not determinable as fruit juice or cordial, or as sugar-free versus sugar-sweetened; these distinctions are important for associations with obesity and health (Chapter 3). Another limitation in dietary data was servings of sweets: sweets were less consistently associated with other variables, compared to servings of fruit and vegetables and pre-prepared foods. I proposed that this could be due to routine-led parents allowing sweet treats, hence provision of sweets being less varied between routine-led and routine-free parents compared to other food groups; or due to routine-free parents allowing their children to help themselves to sweet snacks, and parents therefore not being able to report them accurately. The lack of evaluation of the size of servings was another major limitation. However, the focus of the dietary section of this study was the types of foods consumed by children, rather than precise nutritional content. The hypotheses generated in this study regarding food intake (the dietary aspects of the Behavioural Mechanisms Hypothesis) should be tested in future research using more detailed and validated dietary assessment methods.

A major limitation in this study was the physical activity data. The diary was designed to assess the time which children spent in physical and sedentary activities. Although there was a clear rationale for using parent-report measures of activity, there were concerns regarding inconsistent reporting between parents, particularly in the types of activities documented, and so physical activity data were not used in analyses. This prevented the exploration of the role of physical activity in the short sleep-obesity link. Further research should build on the literature reviewed in Chapter 3 to explore the mediating or confounding role of physical activity. Assessment of physical activity using activity monitors would have enabled the generation of objective physical activity data; however, similarly to actigraphy, this was avoided due to limited resources, and to minimise participant burden and maximise the participation rate.

Despite limitations in the parent-report method, there are some strengths which increase reliance on the data produced: the diary was piloted prior to use in the main study, parents were given clear and consistent instructions on how to complete the diary and had opportunities to ask questions each day when they filled it in, and validation with actigraphy revealed parents to be accurate reporters. The diary method enabled detailed information to be obtained from each participant: although other methods are able to measure sleep, diet and activity more accurately, the combination of each of these into a single diary limited the burden for participants, and enabled detailed information to be obtained for children over a concurrent 4 day/5 night period. Inclusion of multiple days and nights was an advantage over single estimates or shorter periods; however, longitudinal measurements over longer time periods, including holidays, are needed, to more accurately assess patterns and associations in children's behaviours. Furthermore, the frequency, degree, and impact of any variation in children's behaviours in different households, and in different parenting strategies between caregivers and households, should be considered in further analyses.

Regarding parents' attitudes and practices, the semi-structured interview design enabled the same topics to be explored with each participant, whilst enabling parents to provide unanticipated and spontaneous responses. This was appropriate for exploring parents' attitudes and strategies without prior hypotheses. However, inherent in this design were lack of consistency in specific questions asked, and the possibility of some aspects of parenting being neglected. Based on the hypotheses generated in this study, future research could use validated parent questionnaires or parenting scales to make more statistically sound comparisons of children's outcomes in relation to parenting styles.

Variables

Comparisons were made between participants recruited from nurseries in deprived versus affluent areas. Detailed information regarding SES was not obtained: using occupation or income to categorise families into stratified SES groups would have enabled more detailed examination of SES variation in parents' attitudes and children's behaviours.

Although controlling for risk factors for obesity and short sleep in statistical analyses was not crucial in this exploratory study, there should be consideration of such potential confounding factors. Short sleep and obesity risk vary with gender, SES and ethnicity: both boys and girls, and affluent and deprived families, were recruited in even numbers to this study, to prevent the results from being skewed. The study aimed to recruit families from diverse ethnic groups: as described previously, this was achieved to the maximum potential given the inclusion criteria and the families attending each nursery, but the great majority of participants were white British.

Other factors which strongly influence obesity risk in children include parental obesity, birthweight, and breastfeeding. The number of children who were breastfed for longer than one month was low; and although there were few low birthweight children, data was not available on precise birthweight. The omission of parental obesity is particularly significant due to the strong association which it has with childhood obesity; however, there was a clear rationale for omitting assessment of parental weight status from this study (see Chapter 4). The correlation between parental obesity and child weight status is thought to be partly attributable to shared environmental factors such as dietary patterns (Whitaker et al., 1997): it is likely that parents who were routine-free regarding their children would be routine-free regarding regulation of their own diet and activity, rendering themselves, as well as their children, at increased risk for obesity. Although not supported by this study, I predict that routine-free compared to routine-led parents may be more likely to be obese, in addition to having obese children. Future research should test the hypotheses proposed in this thesis, controlling more rigorously for confounders of childhood short sleep and obesity, particularly parental obesity.

Hypotheses

This study was designed to generate hypotheses for future research, from the perspective of medical anthropology and specifically evolutionary medicine. Approaching the topic from other perspectives, for example psychology or sociology, may have resulted in different interpretation of the results, and generation of alternative hypotheses. Medical anthropology was deemed to be an appropriate perspective from which to explore the topic; future research from other disciplines could complement and extend the hypotheses presented here and provide further insight.

This study focused on behavioural mechanisms and the role of parenting; there are other potential pathways which were not explored and perhaps which have not even been considered to date. This study suggests the importance of parenting and dietary and activity behaviours in the sleep-obesity link, but does not propose that these are the only or even the most significant pathways. Future research should test the hypotheses presented here, and also examine other potential pathways linking short sleep and obesity.

In particular, the literature review presented potential pathways linking short sleep with obesity, which should continue to be explored in addition to those hypotheses presented here. For example, an alteration in leptin and ghrelin as a result of short sleep, leading to increased appetite and food intake, is a proposed causal hormonal mechanism; this could work in addition to, and in harmony with, the Parental Confounding Hypothesis. Children of routine-free parents, with shorter sleep compared to those of routine-led parents, would have an obesity-promoting diet due to the double burden of the direct hormonal effects of their short sleep, and the routine-free strategy of their parents. Other mechanisms outlined in the literature review include increased opportunity to eat, and disrupted glucose regulation in shorter sleepers leading to weight gain; again, these are compatible with the Behavioural Mechanisms Hypothesis and Parental Confounding Hypothesis.

Summary: Study Limitations

There are a number of limitations in this study, particularly attributable to the exploratory design. The lack of prior hypotheses, coupled with the large number of statistical tests, means that there is a possibility of Type I errors. There are limitations inherent in parent-report measures, and the data could have been improved by more thorough and accurate assessment of food intake and physical activity. However, overall, the design and methods were appropriate for the study objectives and were effective at meeting the aims of the study. The consistency of trends in the data, and the support of quantitative data by qualitative data and the literature review, raises confidence in the findings.

Concluding Thoughts

This study explored the sleep-obesity relationship in young children, and applied an evolutionary medicine perspective. The mixed methods design enabled detailed information to be obtained regarding children’s sleep, diet and activity behaviours, and exploration of parents’ attitudes and practices regarding these, and their general approach to parenting.

Why are Short Sleep and Obesity Linked in Young Children?

Based upon the literature reviewed in Chapters 2 and 3, and the results of this study, I propose two main hypotheses to explain why short sleep and obesity are associated in young children:

- Behavioural Mechanisms Hypothesis: *Dietary and activity behaviours contribute to the childhood short sleep-obesity relationship. Proposed mediating behaviours include appetite and obesity-promoting food intake; proposed confounding factors include carbonated drink consumption, distribution of food intake throughout the day (particularly timing of the evening meal); and evening TV viewing.*

- The Parental Confounding Hypothesis: *Parenting strategy confounds the sleep-obesity link in young children, by influencing children's sleep, food intake and activity (compared to routine-led parenting, routine-free parenting is associated with children's shorter sleep and increased risk of obesity, via obesity-promoting food intake and activity). Parenting mediates the association between SES and children's health (higher SES parents are more likely to be routine-led, and lower SES parents are more likely to be routine-free; children in lower SES groups are at greater risk for short sleep and obesity compared to those in higher SES groups).*

The Behavioural Mechanisms Hypothesis and the Parental Confounding Hypothesis are compatible with each other and could co-exist, since parenting can influence each component of the Behavioural Mechanisms Hypothesis (children's sleep, dietary and activity behaviours, and risk of obesity). For young children, parenting may be particularly important since parents have the most influence at this age; hence I propose that the Parental Confounding Hypothesis may be the most influential for preschool children.

Previous research into the pathways linking short sleep with obesity has focused on hormonal mechanisms, for example sleep-related changes in leptin and ghrelin (Chapter 2). I acknowledge that these pathways are likely to be important aspects of the short sleep-obesity relationship, and I do not wish to underplay their involvement; the pathways proposed in this study are not competing alternatives, and could co-occur with hormonal mechanisms (see above). However, I believe that confounding by parents is a significant yet overlooked component of the sleep-obesity link, and that this may be a more influential pathway for young children. At preschool age, parents have the greatest influence on children's sleep, food intake and activity. Even if hormonal pathways extend to early childhood, short sleep would only be associated with children's risk of obesity if parents were to allow children's appetite and food preferences to extend to food intake and weight gain.

Who is to Blame?

I wish to strongly emphasise that I do not in any way "blame" routine-free parents. They have a strategy of parenting which makes sense to them, and which they do not intend to be neglectful or less child-centred; indeed, some parents described their routine-free parenting behaviours in terms of enabling child preference and child choice, thereby rationalising them as being more indulgent of their children. I hope to have presented in this thesis that routine-led and routine-free are two different, equally rationalised parenting strategies. I have tried not to impose my own cultural values and imply that routine-led parenting is "right" and routine-free parenting is "wrong"; rather, the negative connotations of routine-free parenting are evidence-based. Routine-free parenting is associated with shorter sleep and greater risk of obesity for children, and is therefore not as viable and optimal for children's health in this context as is routine-led parenting.

Parents are responsive to their wider social and cultural context. We may need to re-address attitudes of Western culture and whether they are appropriate or optimal for children. For example, within the cultural constraints of Western society, routines and regulation are needed to ensure adequate sleep for young children. Whilst parents are able to overcome these constraints by employing routine-led parenting strategies, this would not be necessary if there was accommodation of more fluid and flexible sleep schedules for children. Judgements regarding desired and suitable sleep patterns are influenced by expectations and culture (Wiggs, 2007): in this sample, a negative perception of napping was clear. More parents tried to prevent naps compared to allowing or encouraging them; napping was associated with lack of regulation and limit-setting, and routine-led parenting behaviours were negatively correlated with daytime napping. Perhaps British cultural attitudes should be challenged, so that preschool children's daytime napping becomes more expected and acceptable. (Note that currently in America, preschool children are encouraged to nap in day-care settings, and are expected to nap until a later age.) In this case, research should focus on determining whether there is an appropriate age to stop napping, and whether continuing napping until an older age can be detrimental. A change in nighttime sleep schedules, particularly in rise times, would be more difficult, given the rigidity of parents' and siblings' work and school schedules, and of children's nursery schedules.

Routines and Regulation

The positive consequences proposed for routine-led parenting are based on routines and regulation of children's behaviours. However, I am not advocating fixed routines for all families. In fact, it is likely that some scheduling regimes can be *too* rigid. An example of such a regime is that of Gina Ford: her best-selling parenting book (The Contented Little Baby Book) and subsequent publications have described to thousands of parents a routine of sleeping and eating at strictly prescribed times, with no deviation, and beginning at a very young age. As described throughout this thesis, parents must negotiate the competing needs and schedules of their child and the whole family. Rather than meeting strict, pre-defined schedules and regulations, I propose that an attitude of parental responsibility and authority over their children's sleep, diet and activities, and resulting monitoring and regulation, could positively impact children's health.

Implications of the Parental Confounding Hypothesis for Public Health and Policy

Confounding by parenting strategy implies that short sleep is not directly associated with obesity, but that the two appear to be related due to their mutual association with parenting. Again, I do not wish to propose that a direct association of short sleep with obesity does not exist at all. However, this direct relationship may have been overemphasised in the literature, whilst confounding explanations have been neglected. This has implications for the conclusions drawn and future directions proposed on the basis of epidemiological data.

The strength and consistency of the short sleep-obesity relationship has caused researchers to propose that obesity interventions should target sleep (Chapter 2). However, the results presented in this thesis suggest that rather than sleep being a potential magic bullet intervention for obesity, the relationship is more complex and multifactorial. A broad, more holistic approach is needed. Rather than simply extending sleep, interventions should consider the wider strategies undertaken by parents. Focusing on a single behaviour (for example earlier bedtime, longer sleep duration) may be ineffective if the wider context in which this behaviour takes place is neglected. It is important to consider the wider determinants of single behaviours; for example, bedtime and sleep duration take place in a context of either regulated, structured, child-centred households (routine-led), versus chaotic, child-governing, non-regulated households (routine-free). Changing specific sleep behaviours will not change the overall chaotic nature of routine-free households, and so children may remain at risk of other adverse health outcomes, including obesity-promoting diets and activity patterns.

Thus, a broader approach is needed to prevent childhood obesity, requiring a change of perspective by routine-free parents. Perhaps interventions focusing on psychological changes in parents and an altering of their perception of parenting could be effective. It has been assumed that:

> "*Every parent knows, children have to be 'put to bed' and have their need for sleep regulated for them.*" (Williams & Crossley, 2008; p. 5)

I have demonstrated throughout this thesis that every parent does *not* know or believe that their children's sleep, and also their food intake and activities, need to be regulated for them. Furthermore, the results presented here indicate that, and support previous conclusions that, regulation of sleep, food intake and activities *is* indeed needed for optimal health and development in young children.

The Parental Confounding Hypothesis proposes that parents in lower SES groups are more likely to be routine-free, and their children at greater risk for short sleep and obesity. A particular focus on families in more deprived areas may therefore be needed. In one of the deprived area nurseries in this study, staff conducted individual voluntary "parenting classes" with some parents, who they felt would benefit, and who agreed to participate. These focused on how to talk to and play with their children, and staff told me that they were well-received by parents. Perhaps a similar approach regarding sleep, and routines and regulation of children's behaviours, could be successful in changing parents' strategies and practices.

The scale of the obesity epidemic and the large proportion of routine-free parents in this sample suggest that more wide-scale intervention may be needed. Group parenting classes are available nationwide (BBC Health). Another widely used form of parental teaching takes place on TV, although this is not evidence-based: programmes such as Supernanny are broadcast to parents, who are advised how to implement the techniques demonstrated in their own households (Supernanny). Thus the idea of educating parents in successful and optimal parenting techniques is recognised; perhaps routines and regulation should form a part of evidence-based parenting teaching. Indeed, lack of advice was highlighted by one mother regarding her preschool child's sleep (Chapter 6); and the majority of parents (three quarters) reported receiving no advice regarding sleep. Parents received most advice informally, from their family and friends, and there was cultural transmission of parenting. Thus there may be a window of opportunity for more formal and evidence-based knowledge transmission regarding parenting strategies and practices.

In sum, the implication of this thesis for public health and policy is that obesity interventions may be more effective if targeted at changing wider parenting attitudes and strategies, rather than targeting individual behaviours such as longer sleep.

Future Directions Reassessed

This study set out to increase understanding of the documented association between short sleep duration and obesity in young children. The future directions proposed in Chapter 1 have been successfully addressed, by the identification of potential mechanisms linking short sleep and obesity, the generation of hypotheses, and the consideration of the wider social and cultural context of the sleep-obesity link. Based on the results presented in this thesis, areas for future research can now be readdressed and refined.

The Behavioural Mechanisms Hypothesis and the Parental Confounding Hypothesis should be tested in large samples, in different populations, and using more rigorous statistical techniques. Particular aspects of the Behavioural Mechanisms Hypothesis should be tested in more detail. Trends identified in this study suggest that the timing of food consumption throughout the day may be associated with both sleep and obesity, in particular the timing of the evening meal, and the consumption of supper. A more thorough examination of food consumption patterns, including the nutritional content of different meals, may shed light on potential mechanisms linking sleep with weight gain. Furthermore, the pattern of results in the study suggests that the timing of TV viewing, rather than total daily duration, is important for children: timing of TV viewing should be explored in more depth, including the factors which contribute to, and result from, late TV viewing in the evening. Now that the importance of parenting in the sleep-obesity link in young children has been proposed and supported, validated procedures for assessing parenting styles could be used, to test whether parenting does confound the sleep-obesity link, and which aspects of parenting are important (for example warmth is an aspect of parenting which is associated with children's outcomes (Chapter 3), but was not measured in this study).

There are a number of characteristics which were not well investigated in this study, and which could be fruitful areas for further study. In particular, limitations in the parental diary method prevented inclusion of physical activity variables in analyses: the potential mediating or confounding role of physical activity should be explored in more depth. Furthermore, incompleteness in night waking data meant that the sleep duration variable used in analyses did not deduct night waking duration from the time between sleep onset and sleep offset. It is unknown whether it is sleep duration per se which is associated with body composition and parenting strategy, or time in bed after sleep onset (perhaps resting time or some other characteristic). Despite clear and consistent instructions, parents did not accurately or similarly report physical activities or night wakings in the diaries, which perhaps indicates that diary report is not a good method for assessing these variables. Subsequent studies could use objective measures such as accelerometry to assess physical activity, and could use actigraphy in the whole sample to assess sleep duration having accounted for night wakings. However, the low proportion of children who maintained wearing the actigraph for the full 5-night period in this study suggests that the participation rate would be greatly lowered if these methods were attempted. Any research study involves a trade-off between the advantages and limitations of different methods, and decisions regarding the best methods for assessing sleep and physical activity would have to be made on an individual basis as appropriate for the particular study design and aims.

The hypotheses proposed in this study are exclusive to young children, and are not intended to explain the sleep-obesity relationship in adolescents or adults. Perhaps the stronger association of short sleep with obesity in young children compared to other age groups (Chapter 2) is attributable to the impact of parenting, which has a more influential role for young children. The co-existence of short sleep with obesity-promoting dietary and activity behaviours could extend to older age groups, but with individuals regulating their own sleep, diet and activities, rather than these being under their parents' influence (for example adults could be "routine-free" for themselves and not regulate their own food intake and activity levels, or promote regulated sleep; or they could be "routine-led" and regulate their sleep, food intake and activity patterns). Future research should examine whether similar principles to those presented in this thesis can be applied to older populations. It is also likely that parents who are routine-led for their children are similarly routine-led for themselves, whilst routine-free parents are routine-free for themselves. It would be interesting to examine whether routine-led and routine-free lifestyles and strategies are maintained within families and across generations.

Given that this study highlighted a lack of advice given to parents regarding preschool children's sleep (Chapter 6), this appears to be a viable area for potential interventions to improve children's sleep, and possibly associated weight status. Examining the potential to improve parents' knowledge of children's healthy sleep, and any impact on children's sleep itself, is a worthy area for further research. I suggested previously that parenting classes may be a potential forum for informing and educating parents. Parenting classes exist nation-wide, and could be systematically investigated for any impact on parents' knowledge and practices, and children's outcomes. For examine, a study could assess parental knowledge and children's sleep before parents attended a course of parenting classes, and at various points during and following the course, to investigate any change which could be attributed to the parenting classes. These classes target general parenting practice and may be able to target the “routine-free” strategy in particular, which is important since this thesis has concluded that general parenting strategies, rather than particular sleep-related practices, need to be addressed in order for both short sleep and obesity to decrease in prevalence. Any investigation into parenting classes could therefore include assessment of general parenting attitudes and strategies, and other children’s behaviours in addition to sleep, including regulation and routine regarding diet and activities.

Another important issue which was highlighted in this study is napping: napping was infrequent and short in this sample compared to reference populations, which may have contributed to the overall short total daily sleep duration. Napping appeared to ameliorate short nighttime sleep, which was supported by the association of body composition with combined total daily sleep rather than nighttime sleep only. However, napping was generally negatively perceived by parents, and when it occurred was mainly opportunistic and spontaneous. Perhaps improving attitudes towards, and opportunity for, napping could positively impact childrens’ sleep duration and associated outcomes. Research into the ability to, and the effects of, extending napping in young children is timely, given the lack of literature regarding napping in children; indeed, the benefits and consequences of combined nighttime sleep and daytime napping versus consolidated longer nighttime sleep are unknown. Napping is an understudied area which should be researched in more depth, and may be a target for interventions to lengthen sleep in young children.

Conclusion

This study was effective at meeting its objectives, which were to explore the short sleep-obesity link in young children, using an evolutionary medicine perspective. It addressed gaps in the sleep-obesity literature by examining behavioural mechanisms and the role of parenting in the sleep-obesity link, and considering the influence of ethnicity, SES, and social and cultural attitudes and values. It built on and improved on previous studies by including assessment of sleep, food intake and activity over an extended period, using an actigraphy-validated parent-report measure of sleep, and including week and weekend sleep, and nighttime and daytime sleep; also by including alternative measures of body composition to BMI alone. It further contributed to existing literature by providing a detailed description of sleep patterns in a sample of 3-year-old children in North-East England.

I want to conclude by providing my opinion to the question:

Should obesity interventions target sleep?

My answer is maybe, but not in isolation. Maybe, because direct causal hormonal mechanisms seem likely; and because sleep is a potentially modifiable behaviour which could have numerous positive health outcomes in addition to potentially lowering obesity prevalence. However, if the hypotheses proposed in this study are confirmed in larger and more rigorous studies, then interventions should not focus on single behaviours alone: the wider determinants of these behaviours, particularly parents' attitudes and strategies, should be considered. Validation of the Parental Confounding Hypothesis would show that sleep duration is a marker for children's lifestyles, which are either regulated and kept in line with conditions optimal for their health and development; or non-regulated, and discordant with conditions optimal for child health and development. Ultimately, a change in the way in which children's environments and behaviours are regulated will enable them to achieve both the amount of sleep, and the balance between energy intake and expenditure, which are in line with their biological needs.

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Appendices

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Appendix A: Information Letter for Headteachers

SHINY study

Sleep Habits IN Youngsters

Dear [*headteacher's name*],

The SHINY study (Sleep Habits IN Youngsters) is an exciting new project recently launched in Stockton to examine variation in sleep habits in preschool children. Sleep can have important consequences for child health, development, growth and behaviour, and so gaining a better understanding of what affects childrens' sleep is important. The SHINY study aims to investigate the causes and consequences of variation in sleep behaviours in 3 year old children, and how child sleep is related to health via diet and activity. We aim to explore children's own ideas about their sleep and its role in their lives, in addition to those of their parents.

We are seeking 80 families with 3 year old children in Stockton who would like to take part. This would involve parents being interviewed about their child's sleep, diet and activity habits, and about their own parenting styles and attitudes. Parents will also be provided with a diary to complete for 4 days detailing what their child eats and what activities they do on these days, in addition to bedtimes and wake times. We would also like to talk to the children themselves (with their parents' written permission) about their experiences of sleep, perhaps using story-telling and painting to stimulate discussions on bedtime and sleeping.

This study is funded by the Medical Research Council and the Economic and Social Research Council, and is being conducted in collaboration with Stockton Sure Start. The researchers have received CRB clearance, and approval has been granted by the relevant ethics committee at Durham University (copies of confirmation of CRB and ethics approval are available on request).

We would like to invite families whose children attend your nursery to take part. If you are willing to be involved then we would like to come to your school's nursery to meet the 3 year old children and their parents, to tell them about this study and to invite them to participate. This could take place some time after the summer break, at your convenience. I would be very happy to come and discuss this with you, and to provide you with any further information that you require.

I look forward to hearing from you.

Kind regards,
Caroline Jones
Lead researcher of the SHINY study

c.h.d.jones@durham.ac.uk
0191 334 0796 Dept Anthropology, 43 Old Elvet, Durham DH1 3HN

For verification of the SHINY study and the lead researcher you are welcome to contact Professor Helen Ball, Director of the Parent-Infant Sleep Lab:
h.l.ball@durham.ac.uk +44 191 33 46207 (office) 40260 (lab)

Appendix B: Nursery Consent Form

Sleep Habits IN Youngsters

To [*name of school*],

Thank you for your interest in the SHINY study; I look forward to working with you.

I intend to interview parents of the 3-year-old nursery children about their children's lifestyles, with a particular focus on sleep. I would also like to give parents a diary to complete for 4 days about their child's diet, activities and sleep on those days. Parents will be given an information sheet and asked to sign a consent form before taking part. I would like to meet parents as they bring their children to, and collect them from, nursery. Interviews could take place either in a private room at nursery, or in the parents' home if they prefer (in which case I will be accompanied).

I would also like to talk to the children themselves about sleep, perhaps stimulating discussion through story-reading and painting. I propose to conduct these discussions in nursery school (if parents provide written consent), and I will be very happy for the nursery teachers to be involved.

I may ask some of the children to wear an Actiwatch for a few days (if their parents provide written consent): this is a small watch-like device which is worn on the wrist and measures sleep duration, sleep quality and activity levels. Since I am also interested in the effects of sleep on development and growth, I may ask parent's permission to measure their children's height and weight.

Once the SHINY study is completed, I will provide parents and the school with a simple written summary, and any other reports as requested.

…………………………………………....
Caroline Jones
Lead researcher of the SHINY study

I agree to the [name of school] participating in the SHINY study as described above

Signed ………………………… Date ………………………...

Name … ………………….... Position …………………….

Appendix C1: Parent Information Sheet: Interview and Diary

Sleep Habits IN Youngsters

Do you have a 3-year-old son or daughter? Would you like to be in the SHINY study? If so then read on!

What is the study about? Sleep can be important for health, development, growth and behaviour, and so it is important to understand childrens' sleep. The SHINY study (Sleep Habits IN Youngsters) looks at how sleep varies between children and how sleep is linked to diet and activity. It also looks at parent's opinions about their child's lifestyle.

What will be involved? Participation is entirely voluntary. If you agree to take part then you will be interviewed for up to an hour in private at a time and place agreed between you and the researcher. You will also be given a diary to fill in for 4 days about what your time your child goes to bed and wakes up, what s/he eats, and what activities s/he does on these days. Your child will put into a group at nursery. The children will be asked about their bedtime and how they feel about sleeping. They will be read stories about bedtime and sleep, and will be able to paint pictures of their bedrooms. When the SHINY study is completed you will be offered a simple written summary of the results.

Confidentiality: Interviews will take place in private and will be tape recorded. The interviews will later be written down and the tapes will be destroyed. The written copy of the interviews will be anonymous and you won't be able to be identified. The researcher will make notes during the interviews, and you can look at these notes and approve them at the end. The researcher will make notes about what the children say in their groups, but children will not be identified by name. Notes, tapes and diaries will be made anonymous and will be stored securely and in accordance with the Data Protection Act 1998. No-one other than the research team and nursery staff will be able to look at the notes or the diaries, or listen to the tapes. Confidentiality will be maintained in all cases, except where there are legal concerns for the child's safety, in which case the research team will have to notify the Health Visitor, GP or social services. This study has been approved by the ethics committee at Durham University. The researcher has clearance from the Criminal Records Bureau. Participation is entirely voluntary. *You may withdraw from the study at any time, and without having to give a reason.*

Contact Details: Researcher: Miss Caroline Jones, Dept of Anthropology, Durham University
Address: Dept of Anthropology, Durham University, 43 Old Elvet, Durham DH1 3HN
Email: c.h.d.jones@durham.ac.uk Telephone : 0191 334 0796

This study is funded by Economic and Social Research Council and Medical Research Council.

Appendix C2: Parent Information Sheet: Anthropometric Measurements

Sleep Habits IN Youngsters

TAKING MEAUREMENTS

What is this section of the study about? For this section of the study, I would like to take measurements of your child. This is because I am interested in how sleep can affect physical growth in children, for example whether children who sleep differently have different weights and heights.

What will be involved? If you agree to take part, then your child will be measured. His/her height, weight, waist size and body fat will be measured. To measure body fat, skinfold thicknesses will be measured at the upper arm and shoulder.

Confidentiality: The results will be anonymous. No-one other than the research team and nursery staff will have access to individual measurements. The results will be stored securely and in accordance with the Data Protection Act 1998. Approval for this study has been granted by the ethics committee at Durham University. The researcher has clearance from the Criminal Records Bureau. Participation is entirely voluntary. *You and your child may withdraw from the study at any time, and without having to give a reason.*

Contact Details: Researcher: Miss Caroline Jones, Dept of Anthropology, Durham University
Address: Dept of Anthropology, Durham University, 43 Old Elvet, Durham DH1 3HN
Email: c.h.d.jones@durham.ac.uk Telephone : 0191 334 0796

This project is funded by Economic and Social Research Council and Medical Research

Appendix C3: Parent Information Sheet: Actigraphy

Durham University

SHINY study

Sleep Habits IN Youngsters

ACTIWATCH

What is this section of the study about? For this section of the study, I would like to measure sleep duration, sleep quality, and activity levels in your child, using a device called an Actiwatch.

What will be involved? Participation is entirely voluntary. If you agree to take part, then your child will wear an Actiwatch for a few days. An Actiwatch is like a normal watch, and it is worn around the wrist. It can be worn at all times. The researcher will show you how to put the Actiwatch on and off. The Actiwatch will measure when your child is awake and asleep, and will measure how active s/he is during the day.

Confidentiality: The results will be anonymous. No-one other than the research team and nursery staff will be able to see individual data. The results will be stored securely and in accordance with the Data Protection Act 1998. This study has been approved by the ethics committee at Durham University. The researcher has clearance from the Criminal Records Bureau. Participation is entirely voluntary. *You and your child may withdraw from the study at any time, and without having to give a reason.*

Contact Details: Researcher: Miss Caroline Jones, Dept of Anthropology, Durham University
Address: Dept of Anthropology, Durham University, 43 Old Elvet, Durham DH1 3HN
Email: c.h.d.jones@durham.ac.uk Telephone : 0191 334 0796

This project is funded by Economic and Social Research Council and Medical Research

Appendix D1: Parent Consent Form: Interview and Diary

SHINY
study

Durham
University

Sleep Habits IN Youngsters

CONSENT FORM

Please answer all the questions, and circle either 'yes' or 'no'.

Have you read the Information Sheet?	YES / NO
Have you received enough information about the study?	YES / NO
Do you agree to you and your child taking part?	YES / NO
Do you consent to the interview being tape recorded? (The tape will only be listened to by the researcher and will be destroyed later.)	YES / NO
Do you understand that you are free to withdraw from the study: * at any time and * without having to give a reason for withdrawing	YES / NO

Signed ....……….................   **Date** ....

(NAME IN BLOCK LETTERS) ....………........................

(YOUR CHILD'S NAME IN BLOCK LETTERS)……………………………………………..

Appendix D2: Parent Consent Form: Anthropometric Measurements

SHINY study

Durham University

Sleep Habits IN Youngsters

<u>TAKING MEASUREMENTS</u>

CONSENT FORM

Please answer all the questions, and circle either 'yes' or 'no'.

Have you read the Information Sheet?	YES / NO
Have you received enough information about the study?	YES / NO
Do you agree to your child being measured?	YES / NO

Do you understand that you and your child are free to withdraw from the study:

* at any time and
* without having to give a reason for withdrawing YES / NO

Signed ....……….................. **Date** ....

(NAME IN BLOCK LETTERS) ....……….........................

(YOUR CHILD'S NAME IN BLOCK LETTERS)………………………………………..

Appendix D3: Parent Consent Form: Actigraphy

Sleep Habits IN Youngsters

<u>ACTIWATCH</u>

CONSENT FORM

Please answer all the questions, and circle either 'yes' or 'no'.

Have you read the Information Sheet?	YES / NO
Have you received enough information about the study?	YES / NO
Do you agree to you and your child taking part?	YES / NO

Do you understand that you and your child are free to withdraw from the study:

* at any time and
* without having to give a reason for withdrawing YES / NO

Signed .... **Date** ....

(NAME IN BLOCK LETTERS) ....

(YOUR CHILD'S NAME IN BLOCK LETTERS)…………………………………………..

Appendix E: Interview Guide

Topics and Questions for Interviews with Main Caregivers

(there will be flexibility regarding the ordering and wording of questions, and the possibility to follow up on other topics which arise during the interview)

SLEEP

What happens at bedtime? Is there a routine? What is it?
Does s/he have a bedtime? Why? How forcefully do you enforce this? Is it ever a struggle to get him/her to go to bed? Who decides on a bedtime? How did you decide on a bedtime? Is a bedtime important for him/her, or for you (and your partner)?
Is sleep important for him/her? Why?
Would it matter if s/he didn't go to bed until late? Why? What would you do?
Is there a length of sleep that s/he needs? What is it? Why? What would the ideal length of sleep be? Does his/her attitude or behaviour change depend on the amount of sleep s/he has had? How? Why? What do you do about it?
Where does s/he sleep? Why? Does it vary during the night, or on different nights?
Do you allow him/her into your bedroom/ your bed? Why? How often?
Do you take him/her to bed or does s/he go on his/her own? Does s/he seem tired at bedtime? What does s/he do in bed before going to sleep? Why? Who decides what s/he does?
How long does it take him/her to go to sleep?
Does s/he wake up much during the night? Why? When? How often? What times? How long for? What happens if s/he does?
What happens in the morning? Is there a routine? Why? What is it?
What time does s/he wake up? Is it a regular time or does it vary a lot? Why does it vary?
Do you have to wake him/ her in the morning, or does s/he wake up on his/her own? When do you wake him/her, and why? What time would s/he wake on his/her own?
What does s/he do when s/he wakes up?
Do you think that he/she has problems with sleep, with getting to sleep or waking too much?
Does he/she nap often, do you like him/her to nap or not, and why?
Have you ever received any advice about your child's sleep; if so from whom?

ACTIVITY

What kinds of activities does s/he do?
What activities does s/he like to do?
Do you think that some activities are more suitable/ desirable than others? Which? Why?
Are there any particular activities that you encourage him/her to do/ not do? Why? How forcefully to do encourage this?
Does s/he like playing inside or outside?
Do you encourage him/her to play with certain toys? Which? Why? How forcefully do you encourage this?
Does s/he like watching TV/ videos? Does s/he like playing video games? How much time does he/she spend watching TV/ videos/ playing video games?
Do you limit their TV watching? Why? How? How strict are you about it?

Does s/he have a TV in the bedroom?
Do you encourage him/her to be active? Why? How? Is being active important?
If s/he wanted to spend all day watching TV rather than playing, would you have a problem with that? What would you do about it?

<u>DIET</u>
What are typical meals? What foods does s/he eat? What foods does s/he like?
What is his/her diet on a normal day?
Do you encourage him/her to eat certain foods that they don't want to eat? Why? How? How forcefully do you encourage this? Does it work?
Does s/he ever refuse to eat food that you give him/ her? What do you do if that happens? Why?
Are there any foods that s/he wants to eat that you don't allow? Why?
Who chooses what s/he eats at meal times and for snacks, and when?
Do you let him/her eat snacks when s/he wants to? Who decides whether s/he can have snacks? When does s/he have snacks? Who gives them out? Who decides what they are?
Are you strict about diet or not? Why?
Do you find that eating different things makes him/her behave differently? How? Which foods? Why do you think that is?
Where does s/he eat? Does s/he eat alone, or with other people? Who?
What times does s/he eat? Are the times regular every day? Who decides when meals are?
Who prepares meals? Who decides what food to eat?
What drinks does s/he like? What drinks does s/he drink regularly?
Does s/he have breakfast regularly? Who decides whether s/he will have breakfast?
What does s/he have for breakfast? Who gives him/ her breakfast? How long is it between him/ her getting up and having breakfast?
Was s/he breastfed or bottle-fed as a baby? Why? How long for?

<u>GENERAL</u>
Describe a normal day, from getting up until going to bed, including meals and activities.
Is there any difference between different days of the week (for sleep/ activities/ diet)?
Does s/he go to nursery? How often?
Do you know much about what happens when s/he's at nursery (including food, activities and naps)? Do you approve? Do you have any control over this?
Does your child often spend time with other caregivers and in other houses (including overnight)? How often?

Does s/he ever refuse to turn off the TV when you say/ eat what you say?
How often does this happen?
Do you have any strategies for if s/he misbehaves? What are they? How did you learn them?
What does s/he do that makes you cross? Do you ever tell him/ her off about things? What? Why? What do you do?
How do you feel about having to discipline him/her? Do you try to avoid it? Would you rather ignore their misbehaviour because it's easier?

If s/he nagged you all day to eat something/ stay up later/ watch more TV, would you let him/ her?
Do you think it's important that parents control what their child's activities/ diet/ sleep patterns? Why? How strict are you about it?

Is there anything else you want to discuss?

BACKGROUND

Other than you and your child, who else lives in your house?
How many bedrooms do you have?
What are the dates of birth of your child, and you and your partner?
How many children do you have? What ages are they? Do they all live in the same house? Where do they sleep?
How old were you when this child was born?
Do you have a partner? Does s/he live in the house? Do you share parenting duties? If so, then how equally?
What is your occupation? If you are employed, do you work in the evenings?
Is your partner employed?
Was your child's birthweight low, or normal?

Sleep Habits IN Youngsters

DIARY

Child's Name ………………………………

Parent's Name ………………………………

Dates complete: Day 1 ………………….
Day 2 ………………….
Day 3 ………………….
Day 4 ………………….

Hello!

Thank you very much for agreeing to take part in the SHINY study.

Your diary is to be used to record information about your child's sleep, what activities your child does, and everything that he or she eats and drinks, for 4 days.

Please read the examples page before completing the diary.

If you have any questions please contact me – phone 07903 077926 or email c.h.d.jones@durham.ac.uk

Thank you!

EXAMPLE PAGE		
Please answer the following questions about your child's sleep **last night**		
1	Where did your child fall asleep last night? (eg. own room, living room)	*Own room*
2	What time did your child fall asleep last night?	*7.10pm*
3	Did your child sleep anywhere else during the night? Where? (eg. parents room) How long for?	*Parent's bed between 2am – 3am*
4	How many times did your child wake up during the night? What times? How long for?	*3 times 2am, 3am and 4.45am, for 5 mins each*
5	What time did your child wake up this morning?	*6.45am*
6	What time did your child get out of bed this morning?	*6.55am*
7	Did your child have a good night's sleep? If not, why? What happened?	*Yes*

What activities did your child do today, and for how long?

What time?	Activities						How long?	Where	Who with?
	Watch TV	Physical Play	Walk	Sleep/ nap	At nursery	Other (please list)			
7am	√						*30 mins*	*Living room*	*On own*
8am		√					*45 mins*	*Bedroom*	*Brother*
9.30am			√				*10 mins*	*To nursery*	*Mum*
11am						*Shopping*	*30 mins*	*Supermarket*	*Mum*
2pm		√					*1 hour*	*Friends house*	*Friends*

Please list all the food + drink your child has today, including all meals + snacks

Food + drink eaten	How much?	How much left over?	Where eaten?	Who with?	Who prepared it?
White toast with butter	*2 slices*	*The crusts*	*kitchen*	*Parents*	*Mum*
Milk	*One small glass*	*None*	*Kitchen*	*Parents*	*Mum*
Apple	*3 slices*	*None*	*Nursery*	*Nursery*	*Nursery*
Banana	*Half a banana*	*None*	*Nursery*	*Nursery*	*Nursery*
Baked beans on white toast	*Half can beans, 2 slices bread*	*Half slice toast*	*Bedroom*	*On own*	*Mum*
	1 small yoghurt	*None*	*Bedroom*	*On own*	*Mum*
Strawberry Yoghurt	*3 biscuits*	*Half biscuit*	*Bedroom*	*On own*	*Mum*
Chocolate biscuits	*One large glass*	*None*	*Bedroom*	*On own*	*Mum*
Lemonade					

DAY ONE/TWO/THREE/FOUR

Please answer the following questions about your child's sleep **last night**

1	Where did your child fall asleep last night? (eg. own room, living room)	
2	What time did your child fall asleep last night?	
3	Did your child sleep anywhere else during the night? Where? (eg. parents room) How long for?	
4	How many times did your child wake up during the night? What times? How long for?	
5	What time did your child wake up this morning?	
6	What time did your child get out of bed this morning?	
7	Did your child have a good night's sleep? If not, why? What happened?	

What activities did your child do today, and for how long?

	What time?	Activities: Watch TV	Physical Play	Walk	Sleep/ nap	At nursery	Other (please list)	How long?	Where	Who with?
MORNING										
AFTERNOON										
EVENING										

Please answer the following questions about your child's bedtime **tonight**

8	Where did your child fall asleep tonight? (eg own room, living room)	
9	What time did your child fall asleep tonight?	
10	What was the last thing your child did before falling asleep? (eg play, bath)	

Please list all the food + drinks your child has today, including all meals + snacks							
	What time?	Food + drink eaten	How much?	How much left over?	Where eaten?	Who with?	Who prepared it?
M O R N I N G							
A F T E R N O O N							
E V E N I N G							

DAY FIVE Please answer the following questions about your child's sleep **last night**		
1	Where did your child fall asleep last night? (eg. own room, living room)	
2	What time did your child fall asleep last night?	
3	Did your child sleep anywhere else during the night? Where? (eg. parents room) How long for?	
4	How many times did your child wake up during the night? What times? How long for?	
5	What time did your child wake up this morning?	
6	What time did your child get out of bed this morning?	
7	Did your child have a good night's sleep? If not, why? What happened?	

Appendix G: Anthropometric Data Sheet

Date ______________________________ Participant number ______

M F

Height 1) ___________________ cm

2) ___________________ cm

3) ___________________ cm

Weight1) ___________________ kg

2) ___________________ kg

WC 1) _____________________ cm

2) _____________________ cm

3) _____________________ cm

Triceps 1) ___________________ mm Intrameasurer error

2) ___________________ mm

3) ___________________ mm 0.4 – 0.8

Subscap 1) ___________________ mm

2) ___________________ mm 0.88 – 1.53

3) ___________________ mm

Appendix H: Codes and Frequencies for Interview Variables which were not used in Analyses

Table H.1: Codes and Frequencies for Interview Variables which were not used in Analyses

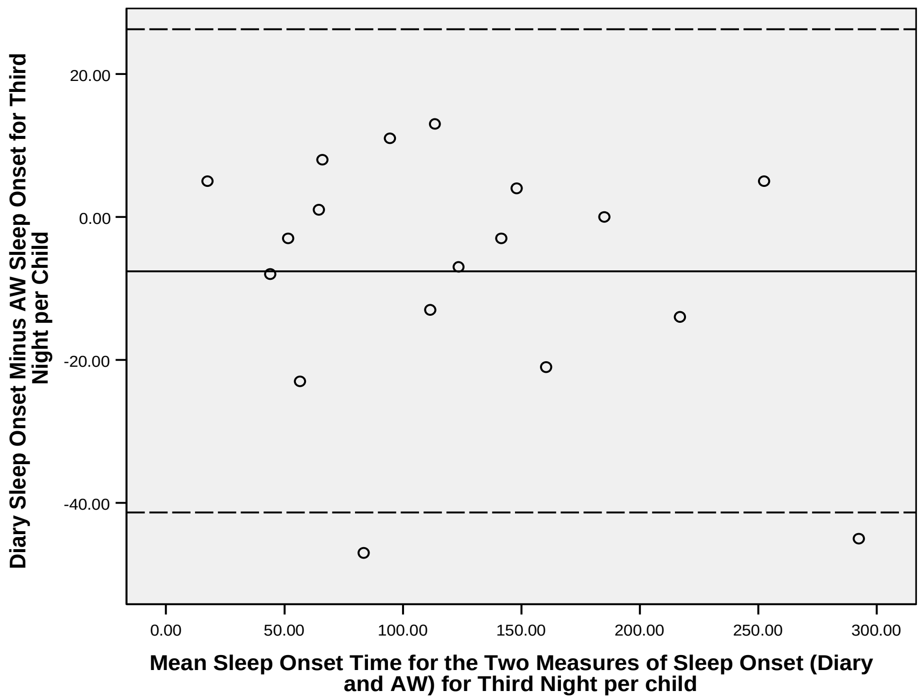
Variable		Codes (frequency of responses)
Interviews: Sleep	Is there usually an adult present when child falls asleep	Yes (n=40) No (n=69)
	Does child object to going to bed	No, or sometimes asks to go to bed (n=59) Objects at least sometimes (n=40)
Interviews: Diet and mealtimes	Parents' attitude towards child's supper consumption	Encourage (n=25) Prevent (n=6) Indifferent (n=44)
	Who does child eat most meals with	Whole family (n=73) Just siblings (n=25) Alone (n=7)
	Does child usually finish eating most meals	Yes (n=60) No (n=43)
	Do parents encourage child to eat unfinished meals	Yes (n=49) No (n=42)
	Are the number of snacks limited	Yes (n=26) No (n=53) Yes except fruit (n=29)
	Frequency of eating meals at cafes or restaurants	Rarely (n=12) Once per month (n=10) Once per fortnight (n=8) Once per week (n=7) More than once per week (n=4)
	Does child watch TV whilst eating	No (n=25) At breakfast only (n=9) Sometimes (n=25) Often (n=14)

Appendix I: Bland-Altman Plots Comparing Diary and Actigraphy Measures of Sleep and Wake Times

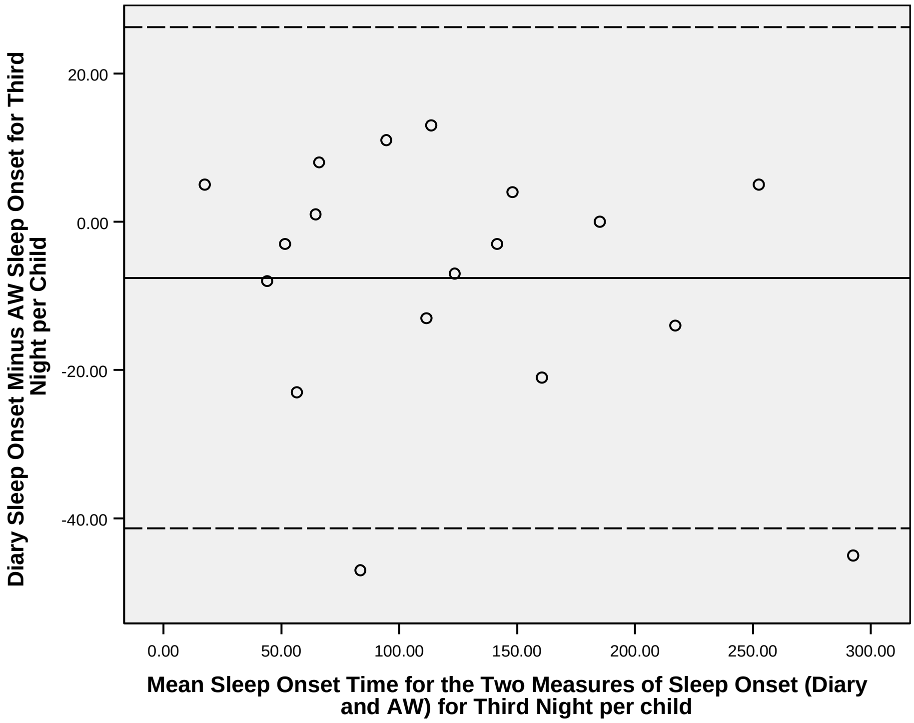
Table I.1 Mean Difference and Limits of Agreement for Different Methods of Measuring Sleep-Wake Times

Measure of Sleep		Mean Difference (Bias) (mins)	Limits of Agreement (mins)
Sleep Onset Time	Mean Across the 5 Nights	-4.3	-27.90 - 19.30
	Third Night	-7.61	-41.48 - 26.26
Wake Time	Mean Across the 5 Nights	-1.68	-11.97 - 8.61
	Third Night	-2.67	-28.58 - 23.24

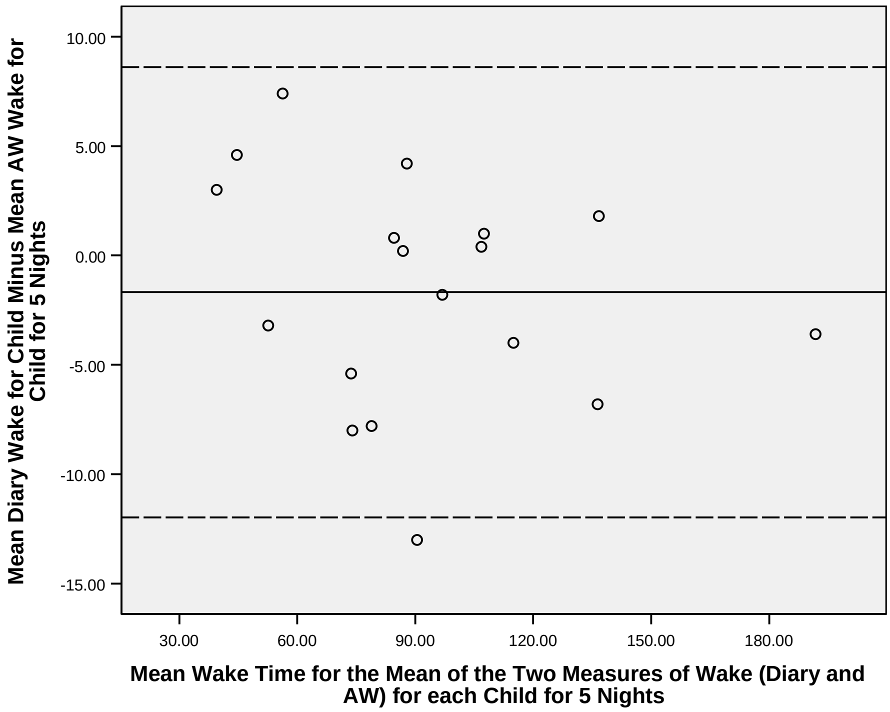
Graph I.1: Bland-Altman Plot for Mean Sleep Onset Time



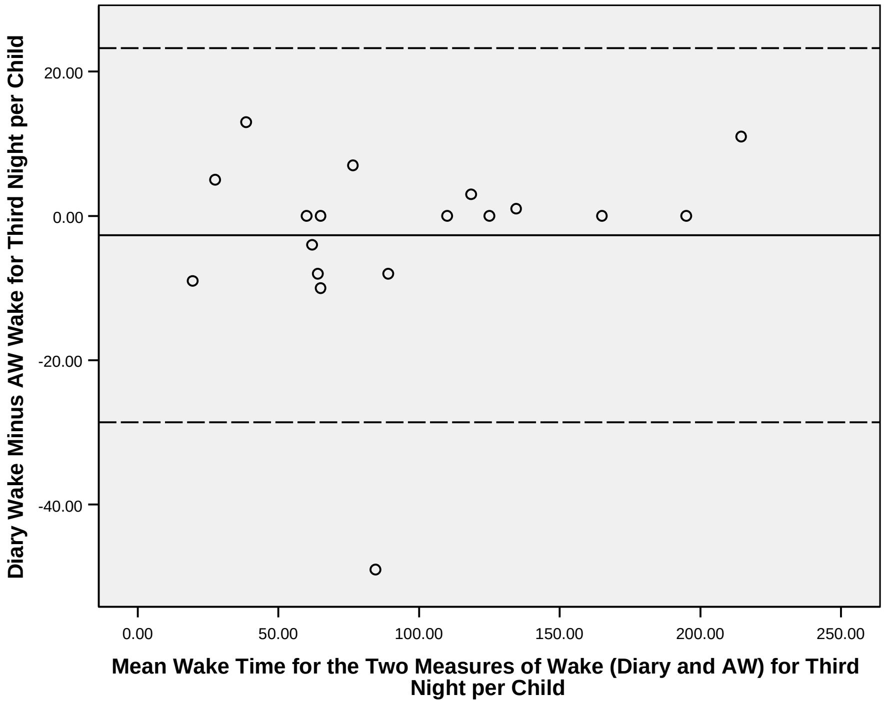
Graph I.2: Bland-Altman Plot for Third Night Sleep Onset Time



Graph I.3: Bland-Altman Plot for Mean Wake Time



Graph I.4: Bland-Altman Plot for Third Night Wake Time



Appendix J: Frequency Tables for Associations of Parenting Behaviours for Children's Sleep

Table J.1: Frequency Table for Setting Regular Bedtimes and Sleep Location throughout the Night

Count		Sleep Location Throughout the Night: Child Rarely Gets into Parents' Bed	Sleep Location Throughout the Night: Child Regularly Gets into Parents' Bed (at least weekly)
Setting Regular Bedtimes	Bedtime Always or Usually the Same	66	16
	No Set Time	10	15

Table J.2: Frequency Table for Setting Regular Bedtimes and Sleep Onset Location

Count		Sleep Onset Location: Child Did Not Fall Asleep on the Sofa	Sleep Onset Location: Child Fell Asleep on the Sofa at Least One Night
Setting Regular Bedtimes	Bedtime Always or Usually the Same	59	8
	No Set Time	8	13

Table J.3: Frequency Table for Setting Regular Bedtimes and Composition of Bedtime Routine

Count		Composition of Bedtime Routine: Parent Usually Reads to/with Child at Bedtime	Composition of Bedtime Routine: Parent Does Not Usually Read to/with Child at Bedtime
Setting Regular Bedtimes	Bedtime Always or Usually the Same	54	25
	No Set Time	8	17

Table J.4: Frequency Table for Composition of Bedtime Routine and Sleep Location Throughout the Night

Count		Sleep Location Throughout the Night: Child Rarely Gets into Parents' Bed	Sleep Location Throughout the Night: Child Regularly Gets into Parents' Bed (at least weekly)
Composition of Bedtime Routine	Parent Usually Reads to/with Child at Bedtime	47	16
	Parent Does Not Usually Read to/with Child at Bedtime	28	13

Table J.5: Frequency Table for Composition of Bedtime Routine and Sleep Onset Location

Count		Sleep Onset Location: Child Did Not Fall Asleep on the Sofa	Sleep Onset Location: Child Fell Asleep on the Sofa at Least One Night
Composition of Bedtime Routine	Parent Usually Reads to/with Child at Bedtime	46	9
	Parent Does Not Usually Read to/with Child at Bedtime	20	12

Table J.6: Frequency Table for Sleep Onset Location and Sleep Location throughout the Night

Count		Sleep Location Throughout the Night: Child Rarely Gets into Parents' Bed	Sleep Location Throughout the Night: Child Regularly Gets into Parents' Bed (at least weekly)
Sleep Onset Location	Child Did Not Fall Asleep on the Sofa	57	11
	Child Fell Asleep on the Sofa at Least One Night	7	14

Appendix K: Frequency Tables for Associations of Parenting Behaviours for Children's Diet

Table K.1: Frequency Table for Restriction of Foods and Child's Usual Mealtime Location

Count		Child's Usual Mealtime Location: Kitchen or Dining Room Table	Child's Usual Mealtime Location: Other Location
Restriction of Foods	Parent Restricts or Bans Certain Foods Totally	54	8
	Parent Does Not Restrict Any Foods	25	18

Table K.2: Frequency Table for Restriction of Foods and Regularity of Meals

Count		Regularity of Meals: Parent Tries to Maintain Regular Meal Times	Regularity of Meals: Parent Does Not Intend to Maintain Regular Meal Times
Restriction of Foods	Parent Restricts or Bans Certain Foods Totally	32	29
	Parent Does Not Restrict Any Foods	11	29

Table K.3: Frequency Table for Restriction of Foods and Children's Access to Food

Count		Children's Access to Food: Child Has No Access to Food, or Access to Fruit Only	Children's Access to Food: Child Has Free Access to Food
Restriction of Foods	Parent Restricts or Bans Certain Foods Totally	50	11
	Parent Does Not Restrict Any Foods	12	33

Table K.4: Frequency Table for Restriction of Foods and Children's Choice of Meals

Count		Children's Choice of Meals: Child Has No Choice for Meals	Children's Choice of Meals: Child Has Some or Free Choice for Meals
Restriction of Foods	Parent Restricts or Bans Certain Foods Totally	30	25
	Parent Does Not Restrict Any Foods	7	30

Table K.5: Frequency Table for Children's Choice of Meals and Child's Usual Mealtime Location

Count		Child's Usual Mealtime Location: Kitchen or Dining Room Table	Child's Usual Mealtime Location: Other Location
Children's Choice of Meals	Child Has No Choice for Meals	31	5
	Child Has Some or Free Choice for Meals	34	20

Table K.6: Frequency Table for Children's Choice of Meals and Regularity of Meal Times

Count		Regularity of Meal Times: Parent Tries to Maintain Regular Meal Times	Regularity of Meal Times: Parent Does Not Intend to Maintain Regular Meal Times
Children's Choice of Meals	Child Has No Choice for Meals	16	20
	Child Has Some or Free Choice for Meals	23	27

Table K.7: Frequency Table for Children's Choice of Meals and Children's Access to Food

Count		Children's Access to Food: Child Has No Access to Food, or Access to Fruit Only	Children's Access to Food: Child Has Free Access to Food
Children's Choice of Meals	Child Has No Choice for Meals	28	7
	Child Has Some or Free Choice for Meals	27	28

Table K.8: Frequency Table for Children's Access to Food and Children's Usual Mealtime Location

Count		Children's Usual Mealtime Location: Kitchen or Dining Room Table	Children's Usual Mealtime Location: Other Location
Children's Access to Food	Child Has No Access to Food, or Access to Fruit Only	53	8
	Child Has Free Access to Food	25	17

Table K.9: Frequency Table for Children's Access to Food and Regularity of Meal Times

Count		Regularity of Meal Times: Parent Tries to Maintain Regular Meal Times	Regularity of Meal Times: Parent Does Not Intend to Maintain Regular Meal Times
Children's Access to Food	Child Has No Access to Food, or Access to Fruit Only	33	25
	Child Has Free Access to Food	10	31

Table K.10: Frequency Table for Regularity of Meal Times and Children's Usual Mealtime Location

Count		Children's Usual Mealtime Location: Kitchen or Dining Room Table	Children's Usual Mealtime Location: Other Location
Regularity of Meal Times	Parent Tries to Maintain Regular Meal Times	36	6
	Parent Does Not Intend to Maintain Regular Meal Times	39	18

Appendix L: Frequency Tables for Associations of Parenting Behaviours for Children's Activities

Table L.1: Frequency Table for Restriction of TV Viewing and Encouragement of Activities

Count		Encouragement of Activities: Parent Schedules Child-Centred Activities Each Week, or Provides Time for Child-Centred Activities Weekly	Encouragement of Activities: Parent Does Not Schedule or Provide Time for Weekly Child-Centred Activities
Restriction of TV Viewing	Parent Restricts TV Viewing (or would if child wanted to watch more)	35	11
	Parent Does Not Restrict TV Viewing	24	32

Appendix M: Frequency Tables for Associations of Parenting Strategies for Sleep, Diet and Activities

Table M.1: Frequency Table for Parenting Strategy for Sleep and Parenting Strategy for Activities

Count		Parenting Strategy for Activities	
		Routine-Led	Routine-Free
Parenting Strategy for Sleep	Routine-Led	43	35
	Routine-Free	3	20

Table M.2: Frequency Table for Parenting Strategy for Sleep and Parenting Strategy for Diet

Count		Parenting Strategy for Diet	
		Routine-Led	Routine-Free
Parenting Strategy for Sleep	Routine-Led	58	24
	Routine-Free	5	20

Table M.3: Frequency Table for Parenting Strategy for Diet and Parenting Strategy for Activities

Count		Parenting Strategy for Activities	
		Routine-Led	Routine-Free
Parenting Strategy for Diet	Routine-Led	37	22
	Routine-Free	9	34