The measurement of motor ability at the secondary school stage

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CHAPTER I

INTRODUCTION

Introduction.

Physical Education as a subject in English state schools is very young, the first official syllabus being compiled in 1904. This century has already seen its development from the age of the sergeant-major-cum-janitor of the early physical training days, who used Swedish and Danish drill, to the modern, college trained, physical educationist who has entered into full partnership with his teacher-colleagues in the nation's schools. One result of this rapid development is that claims are often made concerning the value of the subject which are in urgent need of substantiation before they can be fully accepted or indeed rejected. Some of the claims made, judging from physical education literature, include the fostering of good citizenship, democratic outlook, moral rectitude, good health and posture, self-mastery, and even, by some protagonists, spiritual grace. There is also the stand--ard claim that healthy bodies will in turn make healthier minds. What this means and how it occurs has yet to be scientifically explained. In fact the whole structure of physical education, its aims, and particularly its claims, is ripe for scientific investigation.

Physical education has earned educational respectability in the schools, but has not yet in England fully earned academic respectability, only Birmingham University having so far recog--nised the subject by instituting a degree course in which it is included. The position is very different in the United States of America, where every major university has its physical education department which is at least equal in importance to any other subject. In fact although there are a few research workers in physical education in nearly every country, the United States has by far the most and the research workers of that country have been responsible for nearly all the major develop--ments in scientific investigation and the testing programmes so far in existence.

To quote Postma (1):

"In every mature scientific subject, we find, generally speaking, three kinds of people: practical workers, engineers (the links between science and practical work) and research workers, e.g. nurses - general practitioners - laboratory research workers; labourers - engineers - scientists; or teachers - inspectors - professors of education. Only if sufficient numbers of scientific workers have been trained, can a subject be called mature and the theory be recognised as a branch of science".

Postma concludes:

"About half the fields of the theory of physical education are well developed, the other half however have not yet made so much progress, one cannot unreservedly say that the theory of physical education is scientifically mature. On the other hand one can ask the question: have more mature realms of science, like physics or history, no undeveloped fields of research?"

Physical educationists in England have until the last decade been reluctant to use objective tests, or indeed scientific method in their work, preferring entirely subjective assessments of success or failure mainly because testing programmes have not hitherto been given an important place in College courses. Now some colleges which specialize in physical education have become alive to the necessity of a more scientific approach, and lect--urers, some of whom have been trained in America, have been appointed whose purpose it is to investigate the claims made for physical education and formulate tests and measurements which will help physical educationists in the same way that standard--ised attainment, diagnostic, general ability, special aptitude, attitude and personality tests help the general educator. It is one area of this large field, the measurement of gross motor ability, which is the concern of the present study.

The need for objective testing in physical education is graphically illustrated by a study of Kraus and Hirschland (2) in 1954. They compared the strength and flexibility of trunk and leg muscles between samples of European and American children, using a series of well known physical activities. One table of their results reads:-

	Austrian	Italian	Swiss	American
Number tested	678	1036	1156	4264
Failure (Children failing at least one test)	9.5%	8%	8.8%	57.9%
Incidence of Failure (Number of tests failed)	9.7%	8.5%	8.9%	80%

However one interprets these results the author of this study would suggest that they must have startled American physical educationists.

Adamson (3) working in Leeds about the same time, and using a sample of grammar school boys and university students, made a comparison of scores recorded on strength tests of various kinds by American and English males of the same age groups. He found that only 15% of his English sample attained what the Americans considered to be normal scores. One example was that many English boys could not attempt pull-ups on a high bar where the starting position demanded that their feet should be clear of the ground. Adamson concluded that inadequacy of strength train--ing in schools was responsible for this strength deficiency. In a later study Reid (4) sent a questionaire to 120 schools in which the question, "What are your aims in physical education?" was asked. 76.4% of the schools who replied listed as a main aim the development of physical fitness. Reid later commented on the fact that "Only a very small proportion of the schools seem to make any attempt to assess scientifically any standard of physical fitness".

Comparing Adamson's results with those of Kraus and Hirsch--land, it is difficult not to come to the further conclusion that English boys of the sample compare unfavourably with American children and by inference most unfavourably with the other European nationalities quoted in the Kraus and Hirschland table, so far as strength is concerned. Glover (5) also demonstrated that boys' strength training in Manchester secondary modern schools in 1954 was less than adequate, and said about the modern school boy, "His arm, shoulder and abdominal strength may well be his sole contribution towards further livelihood earning".

One of the firmest held beliefs in physical education has been that a systematic course of remedial exercises could permanently benefit an individual's posture defects, yet Cureton (6) in his 1947 study, found little relationship between posture and performance in normal populations and concluded that there was no evidence that good posture, or indeed bad posture, is a carry over effect from physical education lessons in schools.

If the results of the growing number of objective tests which have been carried out in the field of physical education are accepted as valid, then it follows that physical education schemes must be amended to take advantage of the knowledge gained from them. It also follows that further objective tests in all facets of physical education will help to show the way to further improvement. It appears to the author that the need for a foundation of physical efficiency is becoming ever more import-ant with social advances which bring sedentary modes of life to ever increasing numbers of people . In the past the mass of the lower mental ability groups have earned their living by the use of physical effort and skills, and an effective programme of body building has always been useful for this reason. Now the advent of quicker and more readily available transport, automation and shorter working hours is making life physically much easier at the adult stage, and the formative years at school are becoming, paradoxically, even more important to physical well being. The average schoolboy of today is fast reaching a position comparable with the traditional public schoolboy, a big part of whose education was concerned with physical skills.

Mainly these skills were taught for "character training", but it is often forgotten that socially privileged boys were in need of the physical hardening which was a bi-product of their comp--ulsory games. For the reasons stated above the efficiency of physical education programmes in producing the results necessary for modern life needs to be investigated in the light of accepted statistical methods.

Reading through the files of the National Foundation for Educational Research (7) from 1918 to 1961 the author could find little evidence of any work being done in Britain on the measure--ment of gross motor ability, but the quarterly reports of the American Association for Health and Physical Education of the same period contain many studies which have investigated the possibilities of measuring this ability. It has therefore been necessary to look mainly to American sources for the background to the present study. One of the greatest problems in reading the work of other researchers, particularly in the American world, is the lack of standardisation of terms. Different researchers have coined their own expressions for the same thing and conver--sely on other occasions the same words have somewhat different meanings. It has therefore been necessary to carefully define the meanings of words and phrases in order to ascertain wherever possible exactly what the researcher intended them to mean. Two terms especially need to be defined for the purposes of the present study:

The motor ability of an individual is the capacity, talent or skill of the individual to perform physical activities.

Obviously a test of motor ability is mainly, but not entirely, a measure of physical efficiency at the time of testing. Motor educability says McCloy (8) is the ability to learn motor skills easily and well. It corresponds, in the area of general motor skills, to intelligence in the area of classroom subjects. Tests of motor educability will, therefore, be predictive tests.

Motor ability has been divided into two sections by most researchers as it has become fairly well established that there is little significant correlation between fine and gross motor abilities. Groups of psychologists have studied fine motor adjustment, and have produced tests which give indications of the possession of the type of skill useful in many occupations which demand fine adjustment, like typewriting, draughtsmanship, and piloting an aeroplane. The field with which the present study is concerned is the wider, but as yet more neglected, one of large muscle actions, such as running, jumping, vaulting and climbing, which we call gross motor movements. For reasons which will be stated throwing, catching, kicking and hitting skills, which are involved in ball games, are not within the compass of the study.

C H A P T E R II

STATEMENT OF THE PROBLEM

Statement of the Problem.

There is, so far as the author has been able to ascertain by an intensive study of recorded past research, only one British test which purports to measure gross motor ability (5) and this is restricted in scope to secondary modern school boys in the Manchester area. In this respect we are far behind the Americans who have since the 1920's been studying the subject in schools, colleges and universities, at the same time formul--ating tests to measure either general gross motor ability or prescribed areas of this wide field. The main aim of the present study is to produce a test battery capable of measuring accurately the gross motor ability of boys and girls who have just entered the secondary stage of their education and who will have usually been classified in some way according to their academic ability.

The measurement of intelligence and measures of attainment in the various academic subjects have become an integral part of the educational system of this country and their values are generally recognised, particularly for the purpose of deciding which secondary course is to be followed, even though the recent trend is to disguise the fact that they are being used. Prev-ious research has shown that within the range of normality ther[e] s only a slight and insignificant correlation between [illegible]ce and gross motor ability, therefore the physical [illegible]c is faced with the problem of teaching classes which, [illegible]en formed by considering academic ability only, will [pr]obably include such a wide range of motor ability that a classroom teacher faced with a similar academic range would consider the efficient teaching of such a class virtually imp--ossible. In addition the vast majority of secondary schools draw their annual intake from a variety of primary schools in which the teaching has in all probability varied in standard, the conditions have been vastly different, and the time allotted to physical education has also varied, so that the potential success of the pupils in the common secondary school course is not readily assessable by subjective measures. As a secondary aim the present study will examine the possibilities of measur--ing motor educability by an appraisal of past American research and the selection of what is thought to be the most suitable test for this purpose. The chosen test will be examined statis--tically using a comprehensive British sample of the stated age range.

The author believes that in order to make physical education programmes as effective as possible and to contribute signific--antly to the happy growth of each individual pupil by under--standing and catering for each child's needs, a programme of measurement is necessary now and will become even more so as secondary schools continue their present trend of becoming larger and more impersonal in character. We have become accust--omed since 1944 to talking about kinds of secondary education that are suited to the age, ability and aptitude of the children concerned. We know about age, of course, and can measure it with some accuracy, but ability and aptitude and their measure--ment are rather more complex problems. If attainment is included as well, we have three characteristics that obviously have common features and whose dissimilarities are not obvious to the superficial glance or so sharply focussed as they might be. The author suggests that there is some justification in the field of motor ability for treating attainment as an inclusive term which embraces the other two. When it comes to assessing physical qualities it is only the pupil's attainment, or should we say performance, at the particular moment of the test that is in fact measurable. We find out what skills the pupil has acquired by examining present performance, that is by assessing with what success he can reproduce and demonstrate his skills. Although all tests can in some ways be described as measures of attainment the term tends to be reserved for performance within a precisely defined area such as Mathematics or English. In this case the attainment measured is that of boys and girls in performing gymnastic activities which demand a degree of complex muscular activity. By an ability we refer to a group of skills which may well ignore the boundaries of a prescribed area and may be called into play in a much larger variety of activities. The author's intention in the present study is to measure the gross motor ability of his sample by devising physical tests which will indicate the degree of possession of gross motor ability within the prescribed field of activity, which is indoor gymnastics. However, the skills measured will probably overlap into athletics and swimming, and to a smaller extent to the massive bodily movements involved in the playing of major games. Ball skills are outside the scope of the study owing to the author's belief from his experience and an appraisal of past research that gross motor ability itself may be divided into two major fields, one involving the throwing and kicking of "project--iles" of various kinds and the other the manipulation of the body in space. The word aptitude means something rather differ--ent and indicates prediction or prophecy. Although a pupil may never have been in a gymnasium before he starts his secondary school career the present study will hope to indicate that it is possible to predict confidently that when he does he will be successful or otherwise. The author proposes to do this by indicating the appropriate factors which will bring success in the secondary course and after measuring these as abilities and attainments referring to them in this context as measures of aptitude.

Obviously the best time to administer tests of gross motor ability is at the start of the secondary school career. Some American researchers claim that it is worthwhile to spend up to one tenth of their time in the first year to testing and measur--ing the various abilities and aptitudes of their pupils. The present author's aim is to develop tests which require as little time, equipment and administration as possible, consistent with the attainment of sufficient accuracy to make useful individual assessments, which will certainly enable accurate homogeneous groupings to be formed for the indoor physical education programme. In America the professional school authorities continue to cite the need for a more refined grouping of pupils in physical education to individualize instruction and reduce heterogeneity within groups. Various plans of homogeneous classification have been advocated based on some degree of similarity among individuals, the usual method being some form of ability grouping. The values of this homogeneous grouping include the achievement of higher performance standards, the ready formation of teams of more or less equal ability for competitive purposes, and the possibility of more personal instruction aimed at the improvement of individual weaknesses brought out by the tests. A fair summary of the previous research into homogeneous grouping shows that on balance the slowest pupils are most helped by such groupings. Differing results have been obtained regarding the comparative values which might accrue to bright pupils, but the comments of pupils in the 1951 study of Lockhart and Mott (9) are most illuminating:-

"Comments of the Superior Group:

1. I like the special class, it gives me incentive to try harder.

2. The whole group was more skilled, quicker to respond and more interested.

3. It is more fun and you seem to accomplish more when no one is holding the group back.

Comments of the Inferior Group:

1. I try harder since I don't feel I am making a fool of myself compared to those who are a lot better.

2. In this group I don't feel so inferior or unable to do things.

3. It builds my self-confidence in playing with those who are near my equal."

There are special problems involved in the construction of gross motor ability tests which must be considered generally before the work of devising the test battery begins. These may be summarized as follows:-

1. A test to be retained in the final battery must offer no possibility of injury to any child.

2. Items must clearly discriminate between grades of performance throughout the range from poor to superior. A wide range of scores on an individual item is considered to be important.

3. Consideration must be given to simplicity of terms used which must be easily comprehensible to each pupil and to methods of ensuring clear and effective demonstration of skills where these are necessary.

4. Administrative difficulties which might interfere with the performance level must be eliminated.

5. The equipment used must be generally available or readily improvised. Items involving the simplest of equipment or no equipment at all are the most desirable as not every school has the same equipment.

6. In general, items which prove most reliable in the test-retest situation are held to be superior items. It must be noted here that there are special difficulties arising from the high practice effect of both the Iowa Brace and Johnson tests which are concerned with the measurement of motor educability.

7. Tests should conform to the objectives sought in the physical education programme and to the experience and physical development of the test subjects.

8. To maintain interest and ensure the desired maximum effort, as many of the sub-tests as possible should appeal to the

competitive instincts of the subjects.

9. The sample should be chosen from every type of secondary school, that is Grammar, Comprehensive, Technical, Modern and Special, and therefore from as wide a range of ability as practically possible.

10. The schools chosen should be sited in as many different types of locality as possible, some in the city, some in small towns, some in rural areas. Past research has indicated that considerable variations of performance may be anticipated between say, a school in the centre of a large city and one in a remote country area.

To sum up the chapter, the author believes that measurements of status and progress in physical development are both feasible and essential and that tests should conform to the objectives sought in the physical education programme. The researches which support the views expressed in this chapter have been comprehensively summarised in the ensuing chapters.

CHAPTER III

ON THE RELATIONSHIP BETWEEN MENTAL ABILITY, MOTOR ABILITY AND PHYSICAL CHARACTERISTICS.

(a) The relationship between Mental and Physical Characteristics.

In common with many other educational topics the foundat--ions of study concerning this problem can be discovered in the writings of the Greek philosophers. The greatest discovery of the Greeks was that the world in which man lives is not something foreign to his nature as man, but is in truth an ordered world in which he can work out his own purposes. Writing about the palestra and music schools of his time, Plato (10) said,

> "I believe that teachers of both music and gymnastics have in view chiefly the improvement of the soul".

Plato's inference that the mind functions best in an efficient body was later repeated by Rousseau, "a feeble body makes a feeble mind", and Locke, "a sound mind in a sound body". Thus was the most famous phrase in physical education born.

Aristotle was no visionary, he had a passion for reducing facts to an orderly system, and is thought by some eminent writers to be the first example in history of the modern scien--tific spirit in search of truth. In "De Memoria" lecturing on physical education Aristotle said on the training of athletes, "It is foolish to produce athletes with dull minds as the Spartans do", and even more significantly when discussing the differences between men:

> "Dwarfs and those who have a greater development of the upper part of the body have poorer memories than those of the opposite type because they have a greater weight pressing on the organs of consciousness".

Surely this is the origin of the modern quotation "Strong in the arm, weak in the head".

The inscription "Man know thyself" ran over the portal of Apollo's temple at Delphi, and as man has turned to the Greeks for original inspiration in studying the science of man, the thoughts of Plato and Aristotle have influenced men throughout the succeeding centuries. Genius was thought to be characterised by a puny body and massive head, and the sometimes expressed opinion that less academically gifted pupils are better at practical work than their more gifted peers is only an echo of Aristotle's original comment, springing from the metaphysical concept of unity which, carried to the extreme, leads to a belief in a causal relationship between outer structure and inner function.

Many efforts have been made throughout the centuries to relate an individual's physical exterior to his physical perform--ance and personality characteristics. The phrenologists used cranial capacity and cephalic index. Physiognomists found their clues in the cast of features or particular configurations, and physiologists have even tried carpal development.

Hippocrates first designated two fundamental physical types. Rostan defined three, the "type digestif", the "type musculaire" and the "type cerebral". Kretschmer's three types, pyknic, athletic and asthenic, received considerable attention, but the later work of Sheldon (11) discounted most of the earlier ideas by showing that human beings could not be classified into three physical types, but that nearly all individuals are mixtures of type. Sheldon described eighty eight somatotypes. Although there has remained considerable evidence that the physical pattern is significant in some respects, the concept of body types related to understanding of the individual physically and mentally has been clearly shown to be inadequate in many other respects.

The only pre-twentieth century figure whose results really stand up to modern research is Francis Galton (12), who, in his anthropometric investigation, says:-

> "There is a belief prevelant that men of genius are unhealthy, puny beings - all brain and no muscle - weak sighted and generally of poor constitution ..... I would undertake to pick out of any group of them (the outstanding figures of history) an "eleven" who would compete in any physical tests whatever against similar selections from groups of twice or thrice their numbers taken haphazardly from equally well fed classes".

It was gradually realized by modern researchers that the best method of finding any physical-mental relationship would be the setting of tests involving examples of the use of the qualities to be measured. The pioneer was Porter (13) who in 1897 made an investigation into the mental and physical growth of 35,000 St. Louis schoolchildren. Following the ancient theme, Porter concluded that height and weight did have a significant relationship with mental ability, finding the brighter children heavier and taller, and the duller children lighter and smaller than "average" children of the same age. This is a remarkable study on two counts:-

(1) That it was carried out before Binet began his work in Paris.

(2) The size of the sample, which far exceeds any other the author has been able to find in this field.

Steel (14) comments on this work:-

"On the face of it Porter had some justification for his findings as it seems natural to assume that internal secretion glands, especially the thyroid, might provide a common cause to bring about a definite correlation between body growth and mental development".

More modern studies show that there is some positive relationship between mental and physical traits, but by no means so much as Porter's results would suggest. Steel (14) also quotes the work of Gates, who combined the physical measurements of height, weight, chest girth, lung capacity, grip and nutritional status and ossification with mental age, and found a correlation of only +0.21. Hence he concludes, "Even at best the relationship is slight". Burt (15) in 1937 compared the heights and weights of normal and backward children, finding a correlation for boys between height and mental age of + 0.481 and between weight and mental age of +0.381. Burt concludes "The existence of some connection between mental and physical development all through the years of growth cannot be questioned". Oliver (16) in 1962, studying backward children, found a low but positive relationship between the physical and mental characteristics of children, which tends to increase the further intelligence falls below the average. Terman (17) reporting in 1947 his studies of intellectually gifted children over a long period finally con--cluded that the results of physical measurements provided a striking contrast with the popular beliefs of this type of child being undersized, sickly, hollow-chested and nervously tense. Terman stated that in his view these physical traits were more characteristic of the mentally average child than the mentally gifted.

Quoting several American theses Harrison Clarke (18) maintains that many studies have reported little or no relationship between physical measures and mental achievement, but also gives his opinion that these investigations have been correlational in nature and have ignored the levels of intelligence of the subjects. Although this conclusion may seem strange, if one substitutes attainment for "mental achievement" his meaning becomes clearer. It would appear from these studies that the rate of physical growth has some effect on mental growth, a fact which needs to be born in mind throughout the child's school life, although any attempt to judge mental ability by physical characteristics is not likely to succeed sufficiently well for the tests to be of any practical use. Harrison Clarke recognises this when in discussing classification indexes, (i.e. a classification scheme based on age, height and weight), he concludes that although the class--ification index may be found useful in rapid, tentative classif--ications, it is not so valid as other tests proposed for measuring general abilities. Spearman (19) also concludes that "In the realm of gross anatomy research has found no physical correlate of intellect".

(b) Is there a General Factor in Gross Motor Ability?

Psychologists have tended to study fine motor skills by such means as tapping, target aiming and pursuit rotor tests, but they have at the same time so far largely ignored the field of gross motor ability. The research into mental and fine motor ability has been comprehensively performed because of the necessity for finding valid methods of selection for various types of educational courses and jobs demanding such abilities.

In an important study concerning the relationship of fine and gross motor abilities, Seashore (20) came to the following conclusions:

"(1) No overall or "general" positive dependence or inter-relatedness of fine and gross motor abilities has been found.

(2) Inter-relationship of fine and gross motor ability is an important one. There are few activities in which we can say that, no or almost no, fine motor adjustments are involved. It does not, however, follow that high ability in fine motor co-ordination must be positively correlated with high quality of gross motor co-ordination".

Some psychologists deny, or appear to deny, that there is any correlation between motor ability and intelligence. Spearman (19) says:

"Take even motor ability, by many experts this is unhesitatingly rejected from the scope of intelligence, yet others as confidently declare that the power of co-ordinating move-ments has just as much right to be called intelligent as that of co-ordinating ideas."

The conflicting views of Spearman's "Monarchic" and Thurstone's "Oligarchic" theories, one of which established a general factor "g" and the other denied its existence, have raised a similar question in the field of motor ability; is there a "general motor ability", or are there in fact overlapping areas of ability, each more or less specific to various gross bodily movements? Spearman ponders the question but gives no clear answer, saying:

"Are we justified in thinking of motor ability in the same way as intelligence with a central factor or are there groups of abilities?"

Glover (5) concludes that taking into account all the assembled research in gross-motor learning up to 1954 there is every indic-ation that gross motor learning is specific (to the skill) and there is no simple single factor of motor educability as visual-ized at this period by Wendler (22) and Metheny (23).

Early in the twentieth century several investigators had suggested there was a common factor in motor ability, on the other hand others using the same material found negative correlations. Analysing the motor abilities of a group of undergraduates Perrin (24) concluded that "Motor ability is not general but specialized". McCloy (8) on the other hand undoubtedly believed in a general motor factor comparable with Spearman's "g". His work was founded on contemporary philosophy and he was attempting to construct a test which, as Glover (5) says, would be to the field of physical education what the intelligence test is to the field of cognative learning:-

> "As the ordinary intelligence tests are really tests of general abstract intellectual capacity, so this is a test of general innate motor capacity".

This would appear to be McCloy's answer to Wayman's (25) question, "Should a motor ability test measure neuro-muscular capacity just as an intelligence test measures brain-capacity?".

Summing up the work done before 1954, Glover (5) postulates the theory that all motor ability tests of the era up to the second world war were only partially successful because of this attempt to find a general factor, that is researchers were seeking a test valid in the whole field of physical activity whereas it has now become apparent that owing to the specific nature of tests of motor ability so far devised it is only possible to create tests which are valid in a certain field. Thus, tests involving ball skills do not necessarily have a high correlation (or indeed any) with skills involved in gymnastics. This is borne out by Brace (26) who, in a study of the learning ability of high school girls in a series of what he calls "stunt type" activities, concluded that the learning of sports type skills (mainly involving ball skills) involved different abilities from those required to learn stunts (that is gymnastic skills) and rhythm type activities. He suggested, therefore, that there must be different types of motor learning.

(c) The Relationship between Mental and Gross Motor Ability.

In a general study in 1906 Terman suggested that comparing "bright children" with "average children" the bright children performed better on mental tests but were inferior in motor tests to the average children. This was the first of a series of elementary studies on this subject which were carried out in the first part of the present century. These studies produced very conflicting results, some agreeing with Terman and others violently disagreeing. These early researches are listed by Oliver (16) in his studies concerning educationally sub-normal boys. Perhaps the most important work for the purposes of the present study being that of Nenzec, Cronin and Brannon in 1933, who, investigating the relationship between intelligence and motor ability as measured by the Brace motor ability tests of normal girls, found negative relationship between intelligence and motor ability and a slight but positive relationship between chronological age and motor ability.

Ballard (27) discussing the findings of American researchers up to 1919 insisted that they had found "a marked correspondence" between mental and motor ability. However, he admitted that their data was derived from practical sources and largely from subjective observations. Ballard believed that the American findings stemmed from the belief in the possibility of finding a "Motor Quotient" comparable with I.Q.

In 1925, Heaton (28) using an American sample of high and low mental ability and measuring height, weight, chest expansion, 75 yards dash, standing broad jump, a throw and push ups, found that those children with high intelligence ratings were superior in physical development to those having low intelligence ratings. In his general conclusions he suggested two reasons for this:-

1. The low mental ability groups come from low income groups, and are, therefore, more liable to malnutrition and illness.
2. The more intelligent try harder.

Two studies, by Kieler (29) and Johnson (30), came to the common conclusion that there was no sign of a significant relationship between physical skill as measured and mental power or general intelligence as measured. The Johnson tests[X] were used in both researches as the measure of physical skill. In his research Johnson claimed that his test battery which consists of ten agility exercises performed on a 15 foot mat eliminated the elements of speed, strength and endurance, skill alone being the factor considered. Johnson's results show a slightly negative relationship between mental ability and his tests (-0.059). These figures are not significantly different from those of Ray (31) who in studying the relationship of Terman-Merrill Test results to tests of physical ability found relationships which ranged from 0.09 to 0.26 depending on the physical test considered. Using a sample covering the whole range of ability from superior to sub-normal Kulcinski (32) in 1945 concluded that the average or normal group were superior to the sub-normal in learning physical skills.

X See "Tests and Measurements in Health and Physical Education", McCloy C.H. and Young N.D. Pages 95 to 98.

The work of Dr. D.K. Brace[x] in this field is of the greatest importance to the present study. Brace was particularly active in the whole field of measuring motor ability, working with samples covering the whole range of mental ability. In one study he used a sample composed of low and high grade mental defectives with I.Q.'s ranging from 23 to 82, with a mean as low as 52.9, and in another a sample containing the highest I.Q.'s available to him. Investigating the rate of learning gross motor skills Brace (33) experimented with the measurement of the speed of learning in terms of the number of trials required to master a skill test, and he found that I.Q. was not a significant factor in the speed of learning the tests. In 1949 Brace (34) in discussing his experiment in the motor-learning of feeble-minded girls, made a summary of his own work on the rate of learning gross bodily motor skills, and also that of McNeeley, McCloy and Milne. He concluded that in the educationally sub-normal range there was some relationship between intelligence scores and the scores in the various physical tests, but in the normal population of children and adults the correlation between intelligence and gross motor learning was approximately zero. Brace pointed out, however, that even in the educationally sub-normal range the relationship between the performance of motor skills and intelligence was too low to have any predictive value. In a later study using the Brace scale with young children aged between 5 and 9 years, Vickers (35) found that a good score on

X See "Measuring Motor Ability", A.S. Barnes & Co, New York, 1927, and other references in present study.

the tests was associated with good abdominal muscles and high intelligence. She noted that the correlation of intelligence and motor ability as measured was not generally significant, but if only the children who made a high or low score in the motor ability tests were then considered for I.Q. scores there was a significant relationship between high intelligence and good motor ability, and inversely a low rating in both intelligence and motor ability. Examining some aspects of the relationship between physical and mental ability Steel (14) in 1948 used athletics and gymnastic skills and I.Q. test results as measured in a sample of 134 boys. The conclusion drawn was that the correlation of the physical tests with the I.Q. tests was positive but not significant, (in the order of 0.166 ± 0.079). A recent British Study by Wright (36) concerning I.Q. and physical ability, using a sample of children whose I.Q.'s ranged from 130+ to 70, produced the following results:-

1. The correlation coefficient obtained between gymnastic tests and I.Q. was -0.0088.
2. The test results, (illustrated by graph, scattergram and table of averages), indicated no significant correlation between intelligence as measured and motor educability as tested.

Wright concluded also that his study emphasised the fact that any class taking Physical Education, which has been selected because of academic ability or I.Q., is likely to contain pupils with a wide range of physical ability.

Studying the relationship of personality traits to motor ability in 1960, Merriman (37) gave personality tests to upper and lower motor ability groups, and found that the upper group scored significantly higher than the lower motor ability groups on measure of poise, ascendency and self assurance, and also on measures of interest. The results of Merriman's work indicate that motor ability may well be related significantly to person--ality traits.

The research on this subject, which is far from complete, would appear to suggest that Oliver (16) was making a fair assessment of the present position when he said:

"There is a low but positive relationship between the physical, mental, emotional and social characteristics of normal child--ren, which tends to increase the further intelligence falls below average."

McCloy's (8) summing up is somewhat similar:

"Almost no signific ant relationship has been found between intelligence quotients and measurements of physical ability. This lack of relationship exists even if I.Q.'s are related to motor quotients. For an indication of ability in physical skills I.Q.'s are useless scores, at least within the zone of intellectual normality that is maintained in the (American) public schools."

CHAPTER IV

MOTOR EDUCABILITY

Motor Educability.

The term motor educability was introduced, or at least popularized if it had been known before, by McCloy (38), whose definition is contained in the introduction to the present study. Wendler (22) described his idea of motor educability as:

> "the innate capacity to learn which manifests itself in the degree of large muscular co-ordination acquired after a reasonable amount of practice as well as the ability to perform new movements relatively well with little or no practice".

Mental intelligence testing occupies an important place in education and psychologists have engaged in much research to identify and measure various "factors of intelligence". McCloy (8) maintains that there are other kinds of intelligence and lists in addition:-

(a) Educability concerning the solution of mechanical or manip--ulative problems, which McCloy has stated correlates on average lower than 0.3 with the intelligence involved in the understanding of general ideas and principles.

(b) Educability re the making of acceptable responses in social situations, which also correlates on average 0.26 with the understanding of general ideas and principles.

(c) Educability re the appreciation and the expression of the aesthetic.

(d) Common sense, which McCloy claims is not necessarily highly correlated with the types of intelligence indicated in (a), (b) and (c).

(e) Motor educability, which is the ability to learn motor skills easily and well. It corresponds, in the area of general motor skills, to intelligence in the area of classroom subjects. Mc Cloy states that there are twenty five factors in motor educability and that while some of these can undoubtedly be cultivated or learned, the others are probably as innate as, for instance, colour blindness.

McCloy (38) in 1934 worked out his "General motor capacity" test. The word capacity is meant to be used as indicating potentiality in contrast to achievement - that is, the test was constructed to measure the limits to which an individual may be developed. In this respect says Harrison Clarke (18), "The General Motor Capacity Test may be compared to an intelligence test". For the motor educability part of his test McCloy used his revision of the Brace Test and as he was then on the staff of the State University of Iowa called it the "Iowa-Brace Test".[x]

The Brace Test had originally been published by Brace (39) in 1927. It consisted of twenty movements which Brace called "stunts", each of which was scored in terms of success or failure. Brace thought of it was a test of motor ability and so included skills which depend for their execution largely on strength. When McCloy revised the Brace Test he applied three criteria to the selection of stunts for his revision:-

"(1) The percentage of individuals passing it increased with age.

(2) It had a relatively low correlation with strength,

X See "Tests & Measurements in Health and Physical Education by McCloy & Young, Pages 85 to 94.

with the Classification Index[x], and the Sargent Jump.

(3) It correlated highly with track and field athletic ability when the Classification Index (or age alone for girls), the Sargent Jump and the strength score were held constant to the athletic events but not to the Stunt, consideration being thus given to greater skill, or, it could be held, to a greater degree of motor educability".

McCloy retained twenty one of the original forty different stunts and incorporated them in six batteries of ten stunts each, which were to be used in the elementary, junior high and senior high schools. The stunts all demand varying degrees of agility, balance, neuro-muscular control and flexibility, all of which he maintains are essential to the measurement of motor educability. McCloy claimed an approximate doubling of the validity of this test. In other words the Iowa Brace test measured motor educab--ility to a much higher degree than the Brace test.

In supporting his claim of the validity of the stunt type test for the measurement of motor educability, McCloy quotes several American studies which show:-

"(a) The high correlation obtained between Iowa Brace tests and athletic events when physical traits were held constant.

(b) A similar high correlation between the sports skill ratings of 155 senior high school girls and the Iowa Brace tests.

(c) A co-efficient of reliability (using the split half

X A device for measuring by formula body size and maturity.

method) of 0.885 for the Brace test.

(d) A correlation coefficient of 0.624 between the scores of a sample of boys who had not previously practised gymnastics in learning ten gymnastic skills and the Stunt tests."

It is interesting to note that Brace (33) himself disagreed with McCloy and concluded that the Brace motor ability test was not a sufficiently good measure of motor learning to justify it being classed as a test of motor educability, though he claimed it was slightly superior to the Iowa Brace tests in this respect.

Johnson (40) in 1932 designed a test battery to measure "native neuro-muscular skill capacity" consisting of ten activ--ities performed on a marked canvas mat. For this battery which its author claimed contained no pronounced elements of strength, speed, endurance, familiarity, strangeness or practice, Johnson reported a validity coefficient of 0.69, but did not state against what criterion he had validated it. He also reported a reliability coefficient of 0.97 using an apparently unspecified number of college men as his sample. The Johnson tests were analysed by Metheny (39) in 1938. Metheny used a sample of Junior High school boys and found a high correlation (0.98) between four of the tests and the whole test. She was therefore able to simplify what had been a long and difficult test to score and at the same time modify the mat used.

Professor Wendler (41), of the University of Iowa, in a personal letter to the author in 1963 stated:

"The Brace and Johnson tests are still in use in this country .... I recommend that you limit yourself to the Brace (Iowa revision) test and/or the Johnson test." In accepting this advice from so eminent an authority it is necessary to report in some detail the researches concerning these tests.

Researches into the Brace and Iowa Brace Tests

As Brace originally intended his test to measure motor ability he used a criterion of achievement at the time of the test, not the ability to learn. In 1941 Brace (33) conducted the experiments previously mentioned on page 28 into the rate of learning gross motor skills. His plan was to measure the speed of learning in terms of the number of trials required to master a skill. Teachers were asked to rate subjectively the pupils in order of ability to learn, and Brace maintains that their ratings were made really on observed athletic ability. He stated:-

"It is quite apparent that the teacher ratings were not made on factors measured by the strength test, the Brace or Iowa Brace motor ability tests since correlations were invariably low regardless of the other variables."

Gire and Espenschade (42) made a different approach to the problem, they decided that a test of motor educability which would analyse accurately the ability to learn, or the aptitude of the individual for learning would contribute to the better understanding of physical performance and provide an effective tool for the administration of the physical education programme. The main purpose of the study was to determine the relationship between the Brace, Iowa Brace and Johnson tests and the achieve--ment and learning by high school girls of specific motor skills.

The skills chosen were all of the "sports" type, that is concerned with the learning of skills used in the American games of basketball, volleyball and baseball. The highest correlations were found to be with the Brace tests, the second highest with the Iowa Brace tests and the lowest with the Johnson test.

Inter relationships of "Motor Educability" Tests.
(N - 195)

	Iowa Brace	Johnson
Brace	0.7664 ± 0.0217	0.2018 ± 0.0512
Iowa Brace		0.4817 ± 0.0410

It will be seen that there is a high relationship between the Brace and Iowa Brace tests, substantial relationship between the Iowa Brace and Johnson tests and only a slight relationship between the Brace and Johnson tests. Evidently these three tests are not measures of motor educability to the same degree. This can hardly be counted a statistically accurate study, because many subjects reported having had previous experience in the skills tested and the number of inexperienced subjects was not enough for reliable statistical study.

McCloy and Young (8) quote some of the studies which have been conducted to investigate the efficacy of the Brace tests in America and conclude that the results obtained in these studies have been conflicting. The validity of the stunt type test for the measurement of general motor educability is, they say, supported by the results of an investigation by Anderson and McCloy (43), which the author of the present study has thoroughly studied, and considers highly significant to the present study so far as girls are concerned. The researchers produced a table of correlations between various tests of motor educability and what they called "Sports ratings" and "sports intelligence" (the quickness with which appropriate sports strategy is devised).

Part of the table is reproduced here:-

N = 155

	Sports Ratings (Rel. = 0.95)	Sports Intelligence
Brace Test	0.706	0.671
Brace Test modified (two trials allowed)	0.668	0.668
Iowa Brace Test	0.682	0.618
Johnson Test	0.678	0.661

If, however, the Sargent Jump was "held constant" (apparent-ly a method used by the Americans of eliminating height, weight and age consideration) the correlation of Iowa Brace test was highest on both counts.

A study by Harshbarger (44) in 1936 used sixteen Brace items. A reliability co-efficient of 0.885 found by the split half method in the way devised by Brace, who realized the high practice effect of his test items, was obtained for the sixteen Brace items and a coefficient of validity of 0.606 was obtained between the records for the twelve best performances in the stunts and the sum of the scores for a comprehensive gymnastic skill test.

Making a factor analysis of motor ability variables in 1941, Larson (45) showed that in his sample of college men the Iowa Brace items correlated fairly highly (0.6094) with his "factor three" which he took to be motor educability, or as he put it:

"Factor three is gross body co-ordination, it being logical to assume that a poorly coordinated person will not be able to utilize proper body mechanics for effective results."

Hatlestad (46) in 1942 attempted to inter-correlate the scores on four motor educability tests and produced the following table:

	Brace 2	Iowa Brace	Hill	Johnson
Brace 1 (Scored,pass or fail)	0.98	0.81	0.64	0.46
Brace 2 (Scored 2-1-0)		0.82	0.67	0.50
Iowa Brace			0.75	0.42
Hill[X]				0.49

It will be seen that the Brace Test (scored in two ways) and the Iowa revision again show close agreement.

Phillips (47) used the Iowa Brace test as a measure of motor educability in studying a series of physical education tests by factor analysis, she stated that:-

"The Iowa Brace test was used as a measure of this quality (motor educability). The communality of this test is only 0.3453 (with the others used) so we can reason that this may be due to a factor not present in the other tests which may be motor educability".

Phillips discovered a correlation of 0.5287 between the Iowa Brace test and her speed factor, and concluded that the success--ful execution of the test may be dependent on the possession of

X See "Tests and Measurements in Health and Physical Education", by McCloy & Young. Pages 87, 91 and 93.

speed. This finding is supported by Wendler (22) who, using a sample of Junior High school boys, found a correlation of 0.676 between the Iowa Brace test and his "velocity factor". It must be stated however that Wendler found in his factor analysis a loading of only 0.300 for the Iowa Brace test on the factor of motor educability and, therefore, made some criticism of the test as a measure of learning. Both studies agreed that strength was not a significant factor in the performance of the tests.

Summarizing his 1946 research, Brace (26) came to the following conclusions:-

(1) "The learning of the "sport type" motor skills involves somewhat different abilities from those required to learn to manipulate the body in stunt type or rhythm type co-ordinations". (i.e. gymnastics).

(2) "Sport Type" skill learning is dependant to a considerable extent upon physical fitness expressed in terms of strength, speed, agility and power".

Following this McGraw (48) in 1949, who apparently discounted both Brace and Johnson tests stated:

> "There is a need in Physical Education for an aptitude test or tests that will measure individual differences in the rate of learning gross bodily motor skills",

and reported a factor analysis of motor learning using 100 Junior High School girls as his sample. McGraw isolated six factors:- (1) Body size, (2) Athletic ability, (3) Motor ability, (4) Physical fitness performance, (5) Dynamic object (i.e. mainly ball) control, and (6) Bodily co-ordination (gymnastics).

The importance of this study was that following on Brace's concept of two types of motor learning it pointed the way to a splitting up of the originally envisaged single motor educability factor into areas of related factors. Several researchers have claimed that the Brace and Johnson tests are measuring of different abilities and McGraw's further conclusion that he saw the possibility of the existence of learning factors specific to distinct skills obviously needs further research. McGloy and Young (8) for these reasons maintained that the present tests (Iowa Brace and Johnson mainly) would eventually prove to be inadequate and would probably be replaced by tests devised to measure single factors or sets of related factors.

A study concerning the ability of a group of college men to learn wrestling skills was reported by Gross (49) in 1956. Two tests of motor educability, the Iowa Brace and Johnson tests were given followed by a six week's programme of wrestling instruction. Three competent judges then assessed wrestling ability. Both zero order and multiple correlations were calcul- -ated in an effort to evaluate the usefulness of the tests in determining the ability to wrestle. Results showed a low correl- -ation (0.40 ± 0.11) between the Iowa Brace and Johnson tests - once again demonstrating that the two tests were not measures of the same ability. The Iowa Brace test forecasted wrestling ability better than the Metheny revision of the Johnson test as the following extract from the results show:-

Correlation of wrestling ability with Metheny Revision	0.332 ± 0.12
Correlation of wrestling ability with Iowa Brace	0.459 ± 0.11

Here the author of the present study points out that as muscular strength is an important factor in achieving success in wrestling, and neither test claims to measure this, the low correlations obtained with both tests may thus be explained. Gross in fact claims that the strength index used gave a better index of the ability to learn wrestling than did the Iowa Brace or Johnson tests.

Two British researchers who have studied the Iowa Brace Test are Oliver and Glover. In choosing his motor educability test as part of a motor ability measuring battery to be used with educationally sub-normal children Oliver (16) considered using the Iowa Brace test and after some experiments with it commented that practice effect was high, but many of the stunts were not likely to be used in general activity, and were there--fore suitable. He found, also, that the test was easy to score and administer. Glover (5) tried both the Metheny-Johnson and Iowa Brace tests before concluding that "so far as could be seen" one test was neither inferior nor superior to the other, however, he finally decided in favour of using the Metheny-Johnson test as his measure of motor educability, mainly because of his interpretation of past researches, which he claimed showed that the value of the Iowa Brace test as a measure of motor educab--ility had never been properly established, although he admitted it had been used by the Americans in many studies for this purpose.

Researches into the Johnson Test

When Johnson (40) set up his test battery in 1932 he reported a validity coefficient of 0.69, but unfortunately did not state against what criterion it was measured. Some years later in a study which has been often quoted by some and much criticised by others, Koob (50) validated the test against the number of trials required for a group of boys to learn ten gymnastic skills. Koob reported a very high correlation of 0.9687 between the Johnson Test and motor educability as he understood the term.

In his factor analysis of motor ability variables (1941), Larson (45) found a correlation of 0.6475 between the Johnson Test and motor educability. As the physical tests used in this experiment were three mainly concerned with dynamic strength and power (chinning, dips and vertical jumps) it is not surprising that the Iowa Brace items had a slightly lower correlation of 0.6094. It is worth noting once again that these two tests scored by far the highest of all tests involved in the study on Larson's factor three (motor educability).

Gire and Espenschade (42) in 1942 produced their table showing the inter-relationship of the Brace, Iowa Brace and Johnson tests,[x] this showed substantial relationship between the Iowa Brace and Johnson tests. The reliability figures quoted for the tests were not particularly high, (Iowa Brace 0.7421, Johnson 0.611), the researchers using the "split half" method for all three. A general conclusion was that none of the three tests

X See Page 37

measured accurately the ease with which 195 girls in Californian Junior High Schools learned new skills in basketball, volleyball and baseball.

McCloy (8) maintains that performance in the Johnson test is subject to significant improvement on retesting and that pupils who have learned elementary gymnastics have an advantage over those who have not practised gymnastics. The reason for McCloy's remarks would appear to be that some of the tests closely resemble gymnastic skills, this particularly applies to tests 5 and 7, which consist of forward and backward rolling. McCloy also considers that the Johnson test is more difficult to score than the stunt type test although he also gives his opinion that the test appears to be the most valid measure of motor educability yet devised.

Metheny's (23) work in 1938 reduced the Johnson test to four items, two of which were of the rolling type.[x] Obviously this increases by a serious amount the influence of practice previously commented on. Glover, as previously reported, considered both Iowa Brace and Metheny-Johnson tests in his study before deciding on the Metheny-Johnson test. Although he found little to choose between them he made his decision "owing to what was brought out in the review of previous research". In his summary he commented that the only conclusion to be drawn from his study was that the Metheny-Johnson tests were obviously measuring something different than the other seven

X The four test items are (1) Front Roll, (2) Back Roll, (3) Jumping half-turn, (4) Jumping full turn.

tests which made up his test battery. He was critical of the "Jumping-Full-Turn" test which his sample found an almost impossible feat, with the result that he modified it in his try out to 180° instead of 360°. He concluded:-

> "The distribution of scores shows that the "Jumping-Half-Turn" test was a fairly good discriminator, but "Jumping-Full-Turn" was far too difficult".

Nearly 70% of the sample failed to score any marks out of ten on this test. Glover was also critical of the forward roll test,

> "because a boy under five feet tall, no matter how badly he rolled, was incapable of exceeding the distance of his allotted half lane", (which is 7 ft. 6 ins. long).

The reliability coefficients found by Glover using the Test Retest method were:

Jump Turn 1. (Jumping Half turn)	0.492
Jump Turn 2. (Jumping Full turn)	0.723
Roll 1	0.793
Roll 2	0.825

As several recent studies have shown the high and uneven practice effect of these particular items it is not surprising that the reliability co-efficients are rather low when the test-retest method is used.

Commenting on tests of motor educability Oliver (16) rates the Johnson test as more difficult to score than the stunt type and says he has found it also took longer to administer. Obviou--sly he is referring to the full Johnson test, and the Metheny revision, having only four items instead of Johnson's ten, largely eliminates these objections.

In studying motor educability with regard to the rate of learning to ski, Ward (51) in 1962 used the Johnson test; apparently the full test was carried out and Ward declared that the Johnson test seemed to be the most acceptable for his purpose, however, he does comment:-

> "One study (that of Koob) has found a high correlation between the time required to learn ten tumbling skills and the Johnson test. Against this it must be noted that the Johnson test involves tumbling skills and that a high correlation may be expected. It was felt that the Johnson test would be more acceptable if it correlated highly with a number of other activities, and that ski-ing might well be one of these activities."

Scores gained on the Johnson test were arranged in rank order and correlated with the assessed rank order of ski-ing ability. There were thirty-one subjects in the group and the rank order of scores on the Johnson test gave rho = + 0.38 with the total rank order of ski-ing ability. It is interesting to note that eleven of the subjects competed in a slalom, in which placings were given on the result of each individual's best time and the Johnson test then gave the results of rho = 0.76 with the rank order of positions on the slalom. Ward asserted that there were some difficulties in the administration of the tests, but did not say in what way. Also that there seemed to be a certain degree of subjectivity within an objective test. One criticism he made was the now familiar one that three of the test items appeared to favour those subjects who had gymnastic experience.

Ward's general conclusion was that scores on the Johnson test did not themselves give an adequate basis for the selection of students for a ski-camp. Another interesting point brought out was that a test of motor educability might be of some value in the selection of students for Physical Education courses, because students on interview may reflect learning rather than potential, owing to the variation of the work in different schools.

Wright (36) in 1963 working in London along lines somewhat similar to the present study, found that the full Johnson test "proved to be quite efficient" in dividing classes into homo--geneous groups, and quotes a correlation coefficient of 0.70 with his internal gymnastic test. He did, however, declare that its one big disadvantage was the time taken for its administration (approximately forty five minutes to test ten pupils with a staff of two masters), and preferred the Metheny revision with which he was able to test thirty to thirtyfive pupils in the same time. Wright obtained a low correlation between the Johnson test and the Iowa Brace test (0.49), and indicated also that in his view the Iowa Brace test "did not prove to be a satisfactory method of selection".

Other Tests of Motor Educability

Harrison Clarke (18) in the most modern edition of his work on measurement in physical education (1959), lists only the original and revised versions of the Brace and Johnson tests. This is in contrast with the book of McCloy and Young (8) (1954), which details several others of general-motor educability including the Hill test (52) and the Carpenter stunt test (53), which are really offshoots of the Brace test, and the Carpenter mat test which is based on the Johnson test. Some researchers have concentrated on specific aspects of motor educability and have constructed tests for all the known ball games, particularly those played in America; balance, both static and dynamic; rhythm; Kinesthesis and athletics intelligence, in the construction of which many ingenious pieces of apparatus have been devised. Most of the individual tests have a correlation of about 0.4 to 0.6 with the established tests of general motor educability, but as yet they have not supplanted the established "general" motor educability tests as McCloy thought they would.

An important research into motor educability so far as the present study is concerned, was conducted by Adams (54) in 1954 at Louisiana State University. From a study of the history of motor educability testing Adams came to the same conclusion as the author of the present study, i.e. that there are two types of motor educability, what he calls stunt type and "sport-type", and what the present author prefers to call, (a) gymnastic and athletic type, and (b) ball skills type. Adams selected four tests for his final battery of "sport-type" learning measures, all of them ball skills, using a volleyball twice and a tennis ball and a basket ball once each. Adams measured his sport educability score by using a regression equation as follows:

Sport Educability Score = 7.2 (wall volley) + 17.3 (Tennis Ball Catch) + 2.7 (Ball Bounce) + 19.2 (Basketball Shoot).

The tests were developed for college men, and Adams claimed a correlation of 0.79 between his four tests and the forty-nine learning tests which he originally studied. Parts of Phase one of the present study may be regarded as complementary in some respects to that of Adams who was at this time concerned only with ball skills.

CHAPTER V

REVIEW OF RESEARCH RELATING TO THE MEASUREMENT OF MOTOR ABILITY.

The Measurement of Motor Ability.

Until the second decade of the present century nearly all the attempts to measure motor ability concerned themselves with either anthropometric measurement or strength or a combination of both. Early workers in the field, like Hitchcock and his pupil Sargent in the 1860's and 1870's, held the belief that strength was the key to all physical prowess, and that it could be assessed in terms of muscle bulk and bodily proportions alone. Physiologists of the period also pointed out the obvious fact that if this was so then motor ability must also depend on the satisfactory working of the circulatory system. McLeish (55) refers to one test battery popular in the 1890's which consisted entirely of physical measurements such as height, weight, lung capacity and speed of simple reactions. In 1912 a college group at Indiana University devised a test of general motor ability, the passing of which earned membership of an athletic fraternity "Sigma Delta Sigma Psi". The test consisted of twelve sections including athletic events, swimming, gymnastics and games skills. Times and distances, or standards of perform--ance were laid down. It is interesting to note that this test has constantly been revised and is still used in some American States. In the following years the change of emphasis from calisthenics to inter-collegiate sports and games greatly influenced the field of measurement and tests of a similar nature to the "Sigma Delta Sigma Psi" test, the original aim of which was to arouse the interest of boys and girls in physical efficiency, were devised. As is usual in a new field of study there was a great tendency at this time to oversimplify the problems involved and as yet test construction had not been thought of in the light of statistical knowledge and techniques; however by the late 1920's some of the techniques developed by psychologists in the field of intelligence measurement were being adapted to physical education problems, and this caused a great amount of re-thinking with consequent advances in testing techniques.

Dr. Brace was early in the field and published his twenty item test in 1927 (39). Brace claimed a reliability of 0.9 for the whole test which he standardized on performances of both sexes between the ages of 8 and 18. Validity was examined against the following two criteria:-

1. Subjective judgment of experts (which correlated in the order of 0.68 with the tests).
2. Performance of track and field events (0.8)

Brace appears to the author to be the first physical education tester to attempt to apply statistical theory to his work. Brace's arrangement of the order of his test shows the obvious influence of the Stanford-Binet method of arrangment - from easy to hard items. The emphasis of testing during the next decade appears to have shifted to the search for a test which would simply measure all round physical ability quickly and with as few tests as possible. In this period the tests devised were usually headed "General .... ", e.g. "A test of General Athletic Ability", by Cozens (56) in 1930, who attempted to classify students through athletic ability, finding a correlation of 0.97 between seven tests designed to measure the elements of motor ability and a composite criterion of motor ability. Cozens also claimed that his test clearly differentiated the athletic and non-athletic groups. "Meanwhile", says Glover (5), "Physical Educationists did not seem to realize fully the specificity of gross motor skills, probably because they had not sufficient psychological skill in dealing with test results". Johnson (40) believed that general motor ability could be expressed as an index and also that motor ability had much in common with mental ability. He seems to have been impressed by the idea of Wayman (25), who asked in 1930, "Should a motor ability test measure neuro muscular capacity just as an intelligence test measures brain capacity?", because Johnson in 1932 stated that his aim was to measure "native neuro-muscular skill capacity". The use of the strength index as a method of measuring motor ability dates from this period and Harrison Clarke (18) quotes especially the work of Rogers, who in 1926 standardized testing procedures and developed norm tables for their interpretation. Rogers found a correlation of 0.78 between his strength index and athletic ability, and in a second experiment found an even higher correlation of 0.81 between the strength index and a series of tests which may be described as all round sports skills. Other devices for the use of strength indices to measure motor abilities may be read in Harrison Clarke's textbook, pages 284 - 290.

The research in motor ability testing up to 1941 was adequately summed up by Larson (45), who classified motor ability test construction into three groups:-

(1) Those dealing with the fundamental elements underlying the performance of the skill measured, such as speed, accuracy, endurance, control of voluntary movements, agility, balance, body co-ordination, sensory motor co-ordination, rhythm, body structure, shiftiness and strength.

(2) Those dealing with the fundamental skills of physical education - running, jumping, vaulting, throwing, kicking, &c.

(3) Those dealing with sports skills such as the skills required in the major ball games.

Section (1) represents the cause, that is it is research into the basic elements of performance. Sections (2) and (3) represent the effect, they are researches into fundamental gymnastic or sport skills.

It is obvious from Larson's classification that by 1940, motor ability researchers were well into what Glover described as the "Period of statistical analysis", which started when McCloy (38) first used Thurstone's multiple factor analysis in his work on the measurement of general motor capacity. However, in spite of his new statistical approach McCloy in 1934 was still thinking in terms of "general" motor capacity and ability.

McCloy's test battery consisted of:

(a) Sargent Jump (Vertical Jump)
(b) Burpee Test (Squat Thrust)
(c) Iowa Brace Items
(d) A Classification Index worked out up to 17 years of age, which measured by formula body size and maturity.
(e) Pull up strength.

McCloy in his criterion used two parts, (a) Motor Tests,

(b) Teacher's subjective opinions (called assessments). One point of interest to the present study was that McCloy used a different criterion for girls, omitting the effect of body size as he had earlier discovered that this added but little to the criterion so far as girls were concerned. The battery was standardized on the performance of 755 children whose age range was not stated (422 boys, 333 girls). Following McCloy's lead several factor analyses were made of either the whole range of motor ability or selected parts, these are summarized below:

1935, Emma McCloy (58), in two experiments analysing stunt type tests found in one three factors, strength, velocity, and large muscle co-ordination: and in the other strength, velocity and dead weight; her definition of dead weight was that part of weight which does not contribute to strength.

1937, Rarick (57) made an analysis of speed in athletic events and found the factors of general strength, velocity, height, arm strength, dead weight and muscle latency. In the same year Coleman (59) working in the field of velocity identified three factors, strength, speed of muscular contraction and weight.

1938, (a) Hutto (60) measuring athletic power in high school boys found the following factors: strength, weight, muscle velocity, structure and an arm strength factor. (He concluded that combinations of velocity and strength measures could accurately predict athletic power).

(b) Wendler (22), analysing a large number of skills commonly used in physical education isolated four main factors, strength, velocity or speed of movement, motor educability, and

-sensori-motor coordination.

(c) Metheny (23) in the study which resulted in the Metheny revision of the Johnson test made a factor analysis of the several tests which she used to measure motor ability, and found three main factors: speed of movement, strength and motor educ--ability.

Of this period Glover (5) says:

> "A study of analyses carried out in the immediate Second World War era reveals evidence of great improvement in the rotation of axes to produce meaningful results from data. Early in the period there is difficulty in interpreting investigation findings, towards the end results can clearly be seen."

and later:

> "There is a general agreement in the analyses despite the wide range of abilities measured and the great diversity of subjects who took part in the experiments."

In his 1940 study Larson (61) analysed some strength tests and found two factors which he called dynamic and static dyna--mometrical strength. By dynamic strength Larson meant the strength used to lift the body weight and propel it. By dynamo--metrical strength he meant the ability to squeeze, push, pull or lift. To measure dynamic strength Larson used dips, chinning the bar and the vertical jump, and concluded that his measure of this factor was about three times more significant in predicting a composite index of motor ability than static dynamometrical strength as measured by back lift, leg lift, pushing ability and hand grip. In the author's opinion this discovery of two distinct strength factors was Larson's main contribution to the field of gross motor ability measurement and dynamic tests have been included in the present test battery in preference to dynamometer operations. Larson (45) followed this in 1941 with an attempt to construct a test of motor ability and to establish a classification scale. Larson in fact constructed two tests, which he called his indoor and outdoor tests. The indoor test which concerns the present study consisted of a dodging run, Bar-snap, chinning, dipping and vertical jump. The multiple correlation of the test with the criterion measure was R = 0.97 and according to Larson the test indicated ability in the basic elements underlying sports skills. (He also claimed the test would predict motor ability to a high degree of accuracy). Larson himself regarded the fact that he used a "one institution sample of rather selected young men" as a serious limitation to his work, and also stated that his classification index is not a norm. In preparing his test battery Larson first selected several well known test items and matched them with elements underlying motor skill performance, his factor analysis revealed four factors which he claimed to represent:

(1) Dynamic Strength
(2) Static Dynamometrical strength
(3) Gross bodily co-ordination
(4) Abdominal strength

Larson argued that it was logical to assume that ability in the selected skills was dependant on factor three, as a poorly co-ordinated person would not be able to utilize proper body mechanics for effective results. Factor four was difficult to describe, the items tending to cluster "seeming to be determined largely by abdominal strength".

A selection from Larson's rotated factor loadings reads:-

No.		Factor one,	Factor two,	Factor three,	Factor four,
5.	Floor Dips	0.5270	0.2831	-0.1127	0.2675
8.	St.Br. Jump	0.6187	0.2595	0.1510	-0.0566
10.	St.H.S. Jump	0.6069	0.1754	0.1385	-0.1385
23.	Chinning	0.7035	0.2883	-0.1817	0.1099

Pondering over his results Larson realized that the question to be answered was, "What was the significance of the factors in terms of a performance criterion of motor ability?". He therefore selected the three dynamic strength items which had the highest correlation with his criterion of motor ability (chinning, dips and vertical jump) and determined their relation--ships with seven other tests not used in his first experiment. The factor analysis again yielded four factors:

Factor 1 gross bodily co-ordination and agility. The side-step test (0.6504) and the zig-zag test (0.5821) showed the greatest rotated loadings with this factor.

Factor II dynamic strength. Highest loading Dips (0.6840), chinning (0.7821).

Factor III motor educability. Brace (0.6094), Johnson (0.6475), showed by far the highest loadings.

Factor IV motor explosiveness. Vertical jump (0.4453), although low this was by far the highest loading in this factor.

Larson's criterion measure used to evaluate the test items consisted of a number of tests designed to measure the various elements underlying motor skills, each test item was correlated with the criterion measure to determine its significance in predicting the criterion. Reading from Larson's table of criterion correlations the Bar-snap recorded the highest correl--ation (0.7723) followed by chinning (0.6965), standing broad jump (0.6803) and the vertical jump (0.6062). To score the tests Larson changed his raw scores to "weighted standard scores", the sum of these being the "Index score". One side issue explored by Larson was the correlation of age, height and weight with motor ability, and even remembering that the sample consisted of 295 college men, his results are of interest to the present study as they show correlations of only 0.1149, 0.0696 and -0.2105 respectively, which would suggest that in measuring motor ability, pure measures of age, height and weight are of little account.

Powell and Howe (62) had in 1939 made a study similar to Larson's in some ways and this produced the Newton motor ability test for use with high-school girls. The test battery was based on an objective criterion of selected strength, power, speed and body co-ordination items and the researchers claimed a multiple correlation of 0.91 with the criterion. The final battery con--sisted of standing broad jump, a "baby hurdle" race and a "scramble" event. This study and part of that of Scott and French (63) in 1950, covering a similar field are fully reported by Clarke (18) and are interesting mainly because of the efforts being made at this time to produce tests which included as few items as possible, obviously in order to cut down the testing time. Scott's original battery[x] included an obstacle race and later she found that even here she had to eliminate the original hurdles and substitute spots on the floor for stools in order to make the test less time consuming, less dangerous and "not a test to be feared". Later Seymour (64) in 1953 and Barrow (65) in 1954 produced test batteries which achieved similar objects in testing college men. Barrow selected first six items from twenty nine and later three items from the same twenty nine which correlated 0.95 and 0.92 respectively with the total score of performances of the whole twenty nine items. Seymour cut down the existing eight item Emory University Test to four sub-tests and using the total score on the full test as a criterion claimed a correlation of 0.987.

Phillips (47) in 1949, examined a series of physical education tests by factor analysis (using Thurstone's method) and concluded that four main factors emerged (1) general strength (2) abdominal strength (3) velocity (speed) (4) an unidentified factor. Two sub-tests of power of interest to the present study were included, the jump reach and the standing broad jump. Phillips claimed that neither test had a high correlation with her factors one and two, the highest (0.6840) being between the standing broad jump and the speed factor and the lowest (0.1914) between jump reach and the strength factor. She accepted the definition of power as "force times velocity", i.e. in this case strength times speed, and naturally from this

X See "Evaluation in Physical Education" by Scott & French (Chapter Vl.)

evidence concluded that the standing broad jump appeared to be a better measure of power than jump reach. Carpenter (66) had ten years previously found a much higher correlation (0.5267) between the Sargent Jump (a version of jump reach) and the factor of power, this discrepency may be due to the difference in methods of administering the tests, as McCloy (67) had even before this concluded that the Sargent Jump was only a valid and reliable test when "standardised, practised and correctly administered".

In making his factor analysis of motor learning McGraw (48) considered previous significance levels achieved in motor tests up to that time (October 1949) and concluded that in tests of physical ability with normally sized samples correlations of under 0.20 were held to have no significant relationship, correl--ations of 0.20 to 0.40 were low but significant, 0.40 to 0.70 had considerable significance and those of over 0.70 were very significant. The reasons why correlations found significant in physical tests are generally somewhat lower than those considered necessary in assessing the value of mental tests seem to the author to be that in order to eliminate all advantages so that comparison can be made in respect of motor ability alone, a complexity of factors embracing functional and structural mechanisma of the body must be taken into account. The question of how important these factors are in the measurement of motor ability has not yet been satisfactorily answered and is still a problem for research.

In March 1952 McHone, Tompkin and Davis (68) investigated the possibility of setting up short test batteries, easily administered, to assess the motor ability of high school boys. In their preliminary survey they expressed the opinion that in small high schools testing, as an educational tool, had been neglected, as a result "pupils lack definite objectives and the instructor is unable to assess the effectiveness of his program". They believed that lacking adequate criteria it was permissable in this context to assess validity satisfactorily through the exercise of "informed subjective judgement". Using a series of nineteen well known activities they produced several short batteries from which modified T scores were calculated. Speed, balance and flexibility were not mentioned as factors of primary importance yet their presence or absence in the subject will obviously affect the subject's score, in fact the researchers agree that the general nature of the test items in their recommended batteries will detract from the diagnostic value of the test, but they claim that this at the same time increases the probability that all factors affecting physical exercise are being measured.

Typical batteries are:-

No. 1. Standing Broad Jump, medicine ball push shot, squat twist and leg raise, for which a multiple reliability of 0.90 is claimed.

No. 3. Standing Broad Jump, medicine ball push shot and leg raise (Multiple reliability 0.92).

No. 6. Standing Broad Jump, medicine ball push shot, dipping on the parallel bars and leg raise (Multiple reliability 0.91).

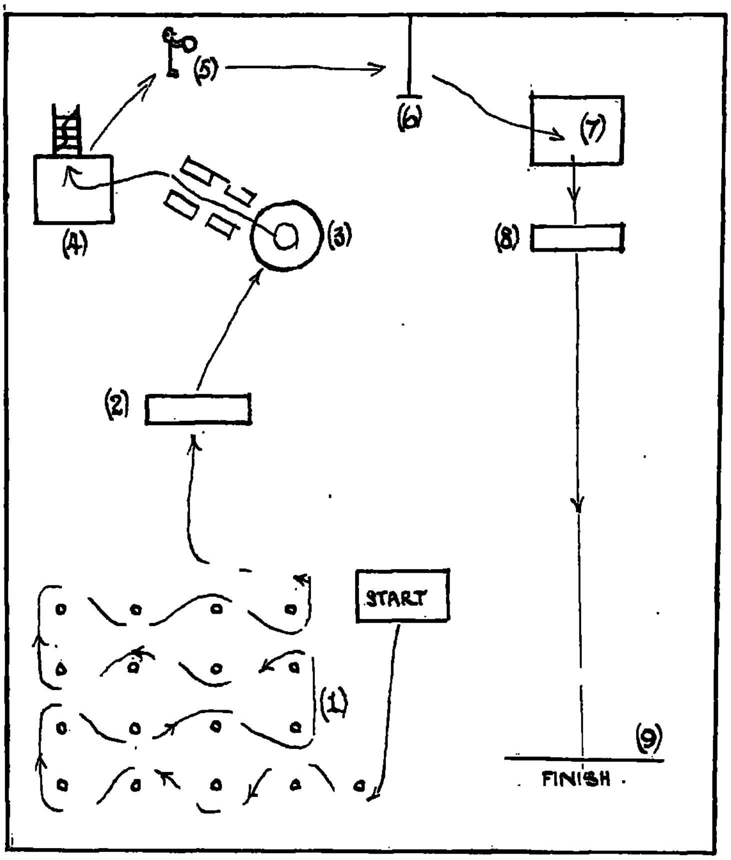
Humiston (69) in 1937 evolved a test for measuring the motor ability of High School girls, this was somewhat unusual as it consisted of a series of tests arranged rather like an obstacle course, or in more modern terms, a circuit training course. The circuit included running, jumping, quick change of body position, getting over obstacles, dodging and hand-eye co-ordination. Advantages claimed for the test were that it could be administered by one teacher, it was economical in time and equipment, and the results could be recorded as a single score. Kammeyer (70) in October 1956 examined the test, modified it, determined its reliability by four trials and its validity by two criteria:-

(1) The performance of the subject in a battery of athletic skill tests, (the rests were Volley Ball volley, Basket ball pass against a wall, Softball throw for distance, Standing Broad Jump and Jump Reach).

(2) The participation of the subject in extra curricular activities, (obviously by this Kammeyer meant activities in athletics).

Kammeyer was disappointed with the reliability co-efficient obtained between the first and second trials (0.428 ± 0.049) but the correlation between the third and fourth trials was 0.85 ± 0.017. The validation results of the test were not clearly stated but Kammeyer's choice of three sports type ball skills as part of her criterion measure of a predominantly gymnastic and athletic type test requires explanation, which was not given in the text. Kammeyer concludes that "the test was found to be a reliable and valid general motor ability test for High School girls".

Kammeyer's adaptation of the Humiston test known as "Olympia" consists of the following circuit course:-



THE "OLYMPIA" MOTOR ABILITY TEST

Line taken by performer shown ⟶

(1) Maze run through 17 chairs
(2) Jump over horse (3'7" high)
(3) Turn in a circle and continue between barriers
(4) Climb and descend perpendicular ladder
(5) Pick up ball from hands of a student
(6) Throw ball over a rope 7 feet high and catch it
(7) Drop the ball and make a lateral roll on a mat
(8) Crawl under a horse (2'9" high)
(9) Run 50 feet to finish line

It must obviously be possible to test more than one pupil at a time on this circuit, providing no part of the course is disturbed by the previous testee, but as time is the vital factor any suggestion of pupils being slowed down by other testees would invalidate the test.

Cumbee and Harris (71) in 1953 listed the correlation of several physical tests with their composite criterion of motor ability without naming the factors involved:-

Factor	Correlation with Factor
Factor A	Standing Medicine Ball Throw 0.647 Sitting Medicine Ball Throw 0.615 Push Shot with Medicine Ball 0.545
Factor B	Potato Race 0.572 Dodge Run 0.451 Circle Scramble 0.251
Factor C	Chinning the bar 0.685 Dipping 0.561
Factor D	Squat Stretch 0.531 Squat twist 0.464
Factor E	Vertical Jump 0.546 Standing Broad Jump 0.473

Factors A and E would seem to be concerned with explosive power, Factors B and D with velocity and agility, and Factor C with strength of shoulder girdle.

Working in Manchester in 1954, Glover (5) using a sample of eleven year old secondary modern school boys evolved a test of motor ability with a view to improving physical education lessons by placing the boys in homogeneous groups for certain activities. Glover fully realized the degree of specificity to be found in factors of gross motor ability and in order to ensure that his tests were valid in content he analysed 242 skills from the physical education scheme of work in vogue at the time in Manchester in order to indicate the relative importance of factors in his particular test battery. The four main factors included in his final battery were:- (1) Strength, (2) Power, (3) Neuro-muscular co-ordination and speed in legs and feet, (4) General motor learning, these were measured by eleven sub-tests. Glover used a composite criterion of validity consisting of two parts, (a) Subjective assessments, (b) the results of an attainment test, and claimed coefficients of reliability on test-retest which varied from a maximum of 0.951 for medicine ball thrust to a minimum of 0.492 for the Metheny Johnson Jump Turn No.1. As Glover did his test-retest normally on one day it is reasonable to expect low coefficients of reliability on the Metheny Johnson Jump Turns because the practice effect is high, also the probable reason that the reliability of the forward and backward rolls test is higher is because the items are well known to the children and practice effect is therefore of much less significance.

Glover's statement of reliability reads:-

Test No.		rtt	N
1.	Press Ups	0.737	215
2.	Pull Ups	0.863	210
3.	Medicine Ball Push	0.951	228
4.	Standing Broad Jump	0.944	231
5.	Jump Reach	0.882	214
6.	Shuttle Run	0.759	220
7.	Squat Thrust	0.761	227
8.	Jump Turn 1.	0.492	94
9.	Jump Turn 2.	0.723	71
10.	Forward Roll	0.793	65
11.	Backward Roll	0.825	65

Making an attempt to classify pupils in a Reading Comprehensive school for physical education lessons, Arnold (72) in 1960 expressed his intention to "measure nature, rather than trained skill" and evolved a battery to measure balance, speed, general ability, muscular power and strength. Although Arnold's work has been criticised on the grounds that he has made assumptions in experimental design and in his evaluation which will not stand up to statistical analysis, he has, in the author's opinion, made a commendable attempt to measure his pupils' ability relative to one another using the gymnastic apparatus which came readily to hand in his particular teaching situation.

Wallace and Biddle (73) working in Middlesex in 1963 on the dynamic strength of fourteen year old schoolboys stated:

> "As a very large number of skills we teach and perform in the course of a boy's physical education lesson depend to a great extent on a moderate degree of strength, we have used tests to measure the dynamic strength of boys of a particular age, hoping that at a later stage we, or others workers, may be able to show they are useful indicators of a child's capacity for motor performance. It seems .... to offer an opportunity to pursue some useful research ...... validating, or invalidating, these tests as measures of motor ability".

Wallace and Biddle accept the findings of Larson concerning dynamic strength and apparently believe in the now largely dis--carded theory that motor ability may be measured as a single strength index.

It would appear that American researchers under the influ--ence of the late President Kennedy have in the 1960's shifted their emphasis on testing to the area of physical fitness rather than motor ability. Actually motor fitness is a limited phase of general motor ability with, according to Harrison Clarke, "emphasis placed on the underlying elements of vigorous physical activity". On the other hand, researchers in Britain have appar--ently reached the stage of attempting to measure both without having as yet ratified the norms of American originated tests using British samples, or to provide British tests which have been statistically ratified. Reid (4) in an article on physical fitness in boys' schools in Britain, published in 1962, adequately summed up the present position when he stated:-

> "Though the majority of teachers mentioned physical fitness as an aim, they are not certain of whether they achieve it or of how to measure it".

CHAPTER VI

THE DESIGN OF THE EXPERIMENT

PHASE ONE

(a) Preliminary Considerations

From a close study of the past research which was quoted at length in Chapters III, IV, and V the author formed the opinion that to exhaustively measure every factor which has been thought by previous researchers to contribute towards making up the whole picture of general gross motor ability, would be a somewhat unrewarding and complicated task. The approach has therefore been to examine the previously reported factors which researchers of the 1930's and 1940's unearthed during the period when statis--tical analysis was in vogue in measuring motor ability and to then decide which of these factors are relevant to the present study. Taking the experiments of five major researchers in the field, Larson (45 and 61), Hutto (60), Rarick (57), McCloy (38) and Cope (74), twenty one major factors emerge, although some of these appear to be due to calling the same thing by different names. Clarke (18) lists nine factors of general motor ability into which the seventeen of the twenty one previously mentioned could be grouped in the following manner:-

Factors of Gross Motor Ability

The Nine Factors of Harrison Clarke	The Seventeen Factors of the five researchers
1. Arm-eye co-ordination 2. Foot-eye co-ordination	1. Arm Control 2. Body Co-ordination 3. Sensory-Motor co-ordination 4. Accuracy 5. Control of voluntary movement
3. Muscular Power	6. Power
4. Agility	7. Rhythm 8. Agility 9. Flexibility

5. Muscular Strength	10. Dynamic Strength 11. Dynamometrical Strength
6. Muscular Endurance 7. Circulo-Endurance	12. Muscular Endurance 13. Dynamic Energy
8. Speed	14. Speed of muscular contraction 15. Velocity
9. B ody Balance	16. Semi-circular - Canal Balance 17. Balance

It will be noted that this table leaves out four of the twenty one major factors noted by past researchers. The first two left out are the factors of weight and dead weight, which the author believes do not need to be specifically measured owing to their effect on the performance of any tests of agility, strength, speed and muscular endurance.[x] The second two, those of speed of motor learning and insight into the nature of the skill, are however of the utmost importance in the present study as they are the only two factors which, it seemed likely, would be predictive in effect. These two factors represent what the author calls the factor of motor educability, which he believes must be included in all batteries purporting to measure gross motor ability.

There seems to be general agreement among American researchers that there is no "g" or general factor in motor ability,

X Glover (5) studied three different methods of assessing body size and its effect on motor ability:- (a) The Classification Index, (b) The Wetzel Grid, (c) Somatotype grading, before concluding that "the evidence indicated that measures of body size contribute very little of value to the battery".

but a pattern where the overall ability is composed of separate and sometimes overlapping group factors, on similar lines to the Thurstone multiple factor pattern. The first question to which an answer was sought was to find the relative importance of the generally accepted major factors of motor ability in the field of physical education which concerns the present study. This is a somewhat similar process to examining curricular validity of the items in an academic attainment test. The method used was to make a careful study of:-

(a) Eight standard text books which contain large numbers of indoor physical education skills and activities (listed under numbers 75 to 82 inclusive in the Bibliography).

(b) Six schemes of work, kindly loaned to the author by colleagues in both boys' and girls' secondary schools (listed under Number 83).

The activities and skills intended for use and development in gymnasia were noted and a list of some 473 items made out including all the orthodox vaulting and agility skills and leading up practices, partner activities, strengthening and mobilizing activities, functional movements, minor games and dance skills. The girls' activities presented a rather more complex problem that those of the boys, as some girls schools concentrate on forms of dance rather than a clearly established pattern of what may be called more orthodox gymnastics. This suggested that either modifications or different types of test might be appropriate to the girls' battery. In fact, only slight modifications were finally found to be necessary. During the preliminary attempt to place the 473 items into ten factor categories (the nine of Harrison Clarke in the table of Factors of Gross Motor Ability plus the additional factor of motor educability) it was realized that:-

(1) The vast majority of strength activities were of the dynamic type rather than static dynamometric. This seems to be one main reason why Larsen found dynamic strength to be three times more useful than dynamometrical strength in indicating motor ability.

(2) A strict definition of muscular strength would be maximum strength applied in a single muscular contraction, (e.g. grip strength applied to a manuometer). However most of the activit--ies studied which might be thought to involve muscular strength were more in the nature of muscular endurance tests, that is they involved the ability to continue sub-maximal muscular exertions. Examples of this include rope climbing and many arm heaves on the beams.

(3) The factors of foot-eye co-ordination and hand-eye co--ordination are taken by the author to refer to skills requiring the co-ordination of hand and eye, such as the cricket skills, batting, bowling and catching, and of foot and eye, e.g. soccer skills, in fact to any skill involving a ball or other projectile. These factors are not of vital importance to the present field of study, although they would be vitally important in the measurement of sports ability. The factors have therefore been grouped with agility, which by definition is the facility to move the entire body in different directions, sometimes in response to unexpected circumstances, sometimes according to a

pre-thought out and practised plan, and balance which is the ease with which an individual maintains body position, (e.g. in hand balance). As all the aforementioned factors are integral parts of what we call neuromuscular co-ordination the combined factor will now be termed simply co-ordination for the purposes of the present study.

(4) There seemed to be a fairly large group of complex vaulting and agility skills where the main factor in success could be insight into the nature of the skill or speed of motor learning. Indeed even in many activities where speed of learning is not the dominant factor it would appear to be generally important in gymnastics. The 473 items were then physiologically analysed and placed in one of the six remaining categories according to their main characteristics. Where there was any doubt into which category the item should be placed the author sought the help of an experienced physiologist.[X] It is perhaps here necessary to re-state that it was not the purpose of the study to exhaustively measure one factor but to measure effectively the group of factors making up the prescribed field of physical activity. Under the strict definition of muscular strength given on pages 75 and 76, many items classified in the following table under this heading could equally well be placed in category 4 (muscular endurance).

X Mr. G. Wright, Senior Physiotherapist, Middlesbrough General Hospital.

Table of Activities from Standard Works on Physical Education and P.E. Syllabuses.

Factor	No. of Items	% age of Total
1. Co-ordination	119	25
2. Power	96	20
3. Muscular Strength	105	22
4. Muscular Endurance	41	9
5. Speed	32	7
6. Motor Educability	58	12
Unclassified	22	5
Total	473	100

From the physiological analysis, from past research on gross motor ability testing and study of the factor analyses made since the 1930's in America, the author concluded that motor ability in the chosen field would best be measured by tests of the following factors:-

1. Co-ordination, sometimes called gross bodily co-ordination or neuro muscular co-ordination or large muscle co-ordination. This may be defined as the ability to change body position or direction of movement under control and involves balance and agility to a large degree.

2. Power, sometimes called muscular power or motor explosiveness, which is the ability to release maximum muscular force in the shortest period of time. It is reasonable to argue that in a human being the mechanical definition of power as force times velocity can be regarded as muscular strength times speed of movement. This factor, therefore, overlaps the factors of strength and speed, being in fact a new factor created by combining the two.

3. Muscular Strength, previous researchers are unanimously

agreed that muscular strength, particularly of the large muscle groups of the shoulders and arms, trunk and legs, is an import--ant factor of gross motor ability. A careful definition of this factor would involve the measurement of maximum strength applied in a single muscular contraction, this would be fairly simple if static dynamometrical strength were the desired factor and the ability to squeeze, push, pull or lift could be registered by dynamometer. Larson's work previously quoted in Chapter III established that dynamic strength tests, that is "strength determined by the ability to lift the body weight and propel it upwards" is three times more significant in producing a criterion of motor ability, and therefore the strength tests should be dynamic in character and possibly linked with the tests of muscular endurance.

4. Muscular Endurance, defined as the ability to carry out muscular contractions of less than maximum operating strength over a period of time.

Taking press ups as a test example, two boys may execute the movement, both apparently working to maximum capacity, but one will be able to repeat the movement several times while the other finds this impossible. It is reasonable to assume that the boy who can repeat the movement is either stronger in the arm and shoulder muscle groups or has greater muscular endurance.

5. Speed, the rapidity with which successive movements of the same kind can be performed.

6. Motor Educability, which has been previously defined and

which involves ready understanding by the performer of the nature of the skill to be learned and the speed at which general motor learning of physical skills is achieved.

Some further points of interest which emerged from the physiological analysis and which were of value in the further planning of the study were:-

(1) There is no doubt that in considering some of the more advanced gymnastic activities it becomes difficult to place such an activity in one particular category when its effective execution is a Gestalt and depends so obviously on a complexity of factors. To give a readily understood example of this, a boy performing a hand balance may be said to be supporting his body weight by use of the large muscles of his arms and shoulders, however the dominant factor in this particular activity was felt to be balance, which within the present definition comes in the general category of co-ordination.

(2) The factors of strength, speed, power and muscular endur--ance overlap considerably and the possibility of using tests involving two or more of these factors became apparent.

(3) The factors of learning and co-ordination appear to over-lap in the same way. In fact McCloy (8) includes balance and sensory-motor co-ordination in his list of factors of motor educability. As these two factors account in the table of activities for 37% of the whole,[x] then obviously the measurement of them must be a most important part of the present study.

X See Table on Page 75.

This was one of the main leads which resulted in the final acceptance of the Iowa Brace test battery for the purpose of measuring both co-ordination and motor educability. McCloy and Johnson agree that the test contains a strong element of gross motor learning and the present author will show later in the Chapter its dependence on the elements of co-ordination.

(4) Larson's (61) previously quoted finding concerning the significance of dynamic strength in measuring motor ability was born out by the break down of arm strength items. Out of one hundred and five items in the whole category, thirty four were concerned primarily with arm strength and of these only eight could be classed as dynamometrical.

(5) In making his analysis, Glover (5) noted that about one sixth of the activities he studied "seemed to rely more on speed and precision of movement" than any other factor. In performing these activities the muscles did not have to work against high resistance, instead they called for "neuro-muscular co-ordination and speed in the legs and feet". The author noted that some of the items particularly in complex relays which were, after consideration, placed in the speed category, might well, under other subjective judgment, have been placed in the co-ordination category. Some of the Iowa Brace items later appeared to be of this type which probably explains Phillips' (47) reported correlation between the Iowa Brace test and her speed factor of 0.5287, backed up by Wendler (22) who reported the even higher correlation of 0.676 between the test and his velocity factor.

(6) The appraisal of past research showed that even if an

American test was accepted in its entirety there would be the need to at least check its validation and establish a scoring system from results obtained from a British sample.

(7) The author fully realizes the scientific limitations of this preliminary work, but has included it to show his trend of thought, at the time, and to point to the reasons for actions which may otherwise have appeared incomprehensible.

(b) Iowa Brace or Johnson for the Measurement of Motor Educability?

A full account of the research into motor educability test-ing was given in Chapter lV. After considering this research the author tried out both tests in four different schools, one secondary grammar, two secondary modern, and one school for educationally sub-normal children, using classes of about twenty to thirty boys or girls. The main reason for doing this was to examine the administrative problems involved in the two tests, to try to iron out any snags which may appear and to make a decision on which to use in the present study.

In three of the schools, the grammar and the two modern schools, the Iowa Brace tests were found to be easy to administer in the way McCloy laid down. The class formed up into two lines of pupils facing each other about eight feet apart. After a demonstration using standard instructions the pupils of one line performed the first five sub-tests scored by the other line. The positions were then reversed and the second line performed all ten sub-tests. The first line then completed the battery by attempting the second five sub-tests.

Regarding the demonstration the author found some difficulty at first with the following three tests:-

(1) Top Test, which needs a very quick movement and real under--standing of the test's requirements for successful execution.

(2) Single Squat-balance test, which the author found to be a very difficult balance position.

(3) Russian-dance step test, which requires finely judged co-ordinated movements, and great strength of the quadriceps.

Noting the high practice effects recorded by previous researchers the author persisted with his practice at the tests and was soon able to perform them all. The author's experience in demonstrating the tests tended to confirm previous research that attempts to measure the reliability of the test by test retest methods would not be successful, and that McCloy's use of the split-half method was justifiable. It was also obvious that it was essential for any demonstrator to practise the sub-tests before giving his demonstration. Groups of twenty pupils were easily tested in a thirty five minute period, and where the author had the assistance of another supervisor to occasion--ally guide and overlook the scorers, double the number could be tested. The reaction of the children to the tests was found to be enthusiastic and the author was subsequently continually being asked to verify that pupils could now perform tests on which they had failed in the test situation.

In the vast majority of cases after a proper explanation and demonstration had been given the pupils were fully capable of scoring fairly and accurately, particularly in the secondary grammar school and in the more academically gifted streams of the secondary modern schools. In two of the secondary modern classes and certainly in all the educationally sub-normal classes the pupils had some difficulty in understanding the instructions. In these classes it was found to be essential to test smaller numbers and to read the instructions slowly and carefully. In the educationally sub-normal classes no more than six pupils at a time could be fairly tested and in several classes individual tests were given.

The ten items of the full Johnson test were tried out using Johnson's original mat diagram. The diagram painted on a sheet of canvas eight feet wide and twenty feet long is a complicated affair,[X] and needs to be pulled taut under an agility mattress or pegged out over grass to be really effective. The tests and scoring proved to be equally lengthy especially as only one pupil at a time could be tested. Therefore after a few attempts the Metheny-Johnson revision of the test was preferred.

Metheny (23), as previously reported in Chapter 1V, found a very high correlation of 0.977 between four of the Johnson sub-tests (5,7,8 and 10) and the full test for boys and a high correlation of 0.868 between three of the sub tests (5,7 and 8) and the full test for girls. At the same time she much simplified the mat.

X For full instructions see "Tests and Measurements in Health and Physical Education", McCloy & Young, Pages 95,96.

Trying out the four items of the Metheny-Johnson revision with boys and the three items with girls the author found no difficulty in demonstrating the first two items (the front and back rolls) and for these the method of scoring was clear although it needed some experience before accurate judgment of performance could be attained. It was found to be essential for the author or the teacher in charge of the class to do the scoring. The second two items, the jumping half turn and the jumping full turn, were much more difficult. Glover (5) who used these tests found them much too difficult for his sample to perform well, especially the full turn jump. Glover in his test battery found it necessary to modify the instructions so that both the half-turn and the full turn became turns of 180° when Johnson clearly intended the full turn to be of 360°. The author's sample found the full turn jump very difficult indeed, no-one scoring a maximum of ten marks and over eighty per cent scoring below three marks. As one mat was used it was only possible to score one pupil at a time and this decided the author to try the full test as a group activity in a normal lesson, although this removed the original objection, the tester's attention was fully taken up with the test performance at the expense of neglecting the rest of the class. It was also necessary to explain and demonstrate each sub test to each group on arrival at the testing point.

From the point of view of administration the Iowa-Brace tests seemed to the author to be preferable for the purpose of the present study because:-

(1) The whole class was involved either in marking or performing during the whole test.

(2) No apparatus, other than score sheets and pencil, was required.

(3) The scoring system was definitely easier.

(4) The time taken to perform the full test was less in every case except those of the educationally sub-normal classes.

Examining the test material itself, in the Iowa Brace test seven of the ten items are common to both boys and girls. Of these none are movements which normally enter into the physical education syllabus. Of the six others concerned the three-dip test consists of what we know as "press-ups" but this is here performed with emphasis on the style of the performance rather than on muscular endurance. The forward-hand-kick test is some--times used as a warming up exercise in both gymnastics and athletics, but none of the others are normally performed. The first two items of the Metheny-Johnson test, the forward and backward roll, are open to the objection that forward and backward rolling are common junior school activities and one must be test--ing in some measure the effect of previous practice. These two tests form half of the test battery and it was most noticable that in one secondary modern school, where the intake was almost entirely from a neighbouring junior school where no indoor physical education facilities exist, the results in these tests were significantly lower than in other schools. A further objection to the rolling items is that boys and girls of eleven years of age and normal height have no difficulty in performing the forward and backward roll in a distance of 7'6", indeed it would require a long dive forward for them to exceed the target line. This was first noted by Glover (5) and confirmed by the author's experience.

Neither of the tests would appear from past research to yield high coefficients of reliability from the test-retest method, this is due to the high practice effect of both tests. Glover found his highest reliability co-efficient in the Metheny Back Roll, which yielded r = 0.825, but the Front Roll test was only r = 0.492. Johnson himself using a sample of college men with his full ten items found a reliability coefficient for the whole test of 0.97, but several other experiments, particularly those with high school girls of the same age range as the present study, have found reliability coefficients in the order of 0.62. The test-retest method has not generally been used with the Iowa Brace items and the ten tests which concern the present study have been split into two halves for the purpose of reliability ratings. McCloy (8) in one study reported a reliability coefficient for the Iowa Brace test of 0.885 and in another along with Anderson (43), using the split half method, of 0.95; but other researchers reported in Chapter IV of the present study have again shown much lower reliability co-efficients.

On the vital matter of validity it will be seen from previous research that results have again varied considerably. It is patently obvious from several researches, notably those of Hatlestad (46) and Gire and Espenschade (42), that the two tests do not measure quite the same thing, and many researchers vary in their conclusions, mainly because of the type of skill being measured. If one accepts the results of Koob (50), who reported a validity coefficient of 0.9687 between the Johnson test and the time taken for a sample of boys to learn ten tumbling stunts then the Johnson test in nearly a perfect instrument, but Johnson himself (40) reported a validity co-efficient of 0.69 and Larson (45) of 0.6475, which seem to be more in keeping with other reported researches. American researchers have again shown varied results concerning the validity of the Iowa Brace tests, most of the test results recording co-efficients of validity in the order of 0.65. Some researchers found higher coefficients, notably Anderson and McCloy (43) with a reported validity coefficient of 0.706, who suggest that some of the lower correlations have been obtained because researchers have tried to correlate the tests with tests of general motor educability made up of artificial activ--ities, neglecting such variables as the background of perform--ers, methods of teaching and motivation.

The author of the present study would suggest from his study of previous relevant research that:-

(a) Both tests are suitable for obtaining results which would assist the physical educationist to form homogeneous groupings for gymnastic or sports activities, but, if one ignores the out--standingly high validity coefficient reported by Koob, neither is alone suitable for the accurate placing of large, randomly selected groups of pupils, in the age range concerned with the present study, into rank order of ability.

(b) There is apparently no general motor educability, but rather groups of motor educability factors which overlap and may need different measures in the various areas of physical skills such as games and sports, gymnastics and athletics.

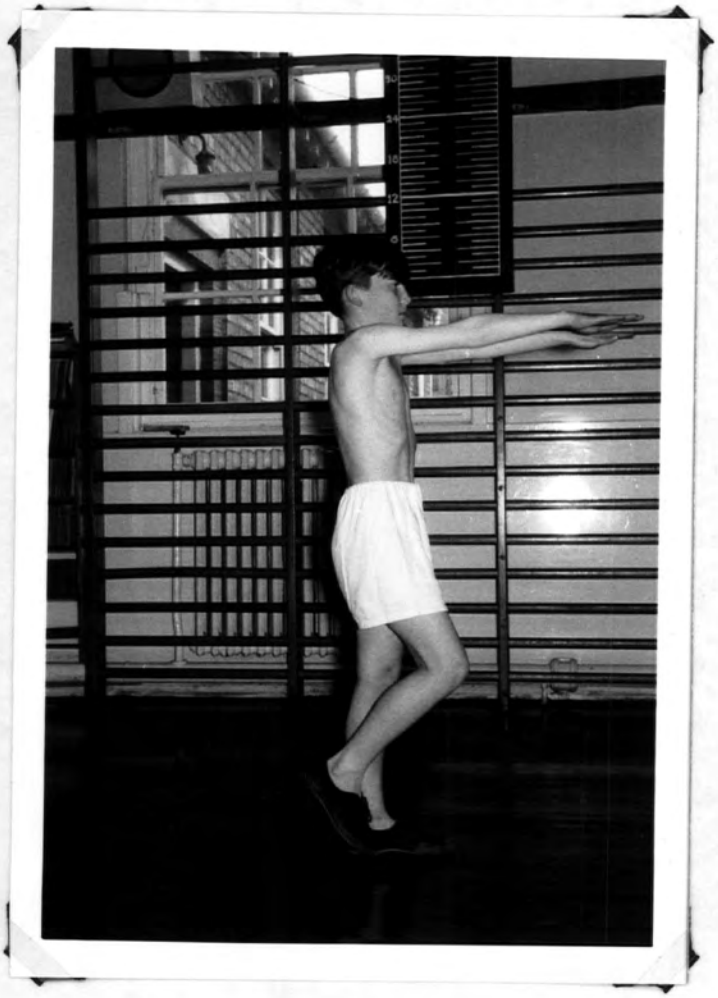
Test results are also shown to vary according to the age range and sex of the sample. It follows from these conclusions that either specific uses for the tests must be found or that other tests need to be formulated for specific purposes.

The Iowa Brace tests were finally chosen for the present study not because the author felt that they were generally superior to the Metheny Revision of the Johnson test on the two vital matters of validity and reliability, but because they seemed better suited for the intended purpose of inclusion of some or all the items in a battery of tests to measure the motor educability factor of gross motor ability at the stated age range and in the prescribed area of ability.

(c) A Physiological Analysis of the Iowa Brace Test Items.

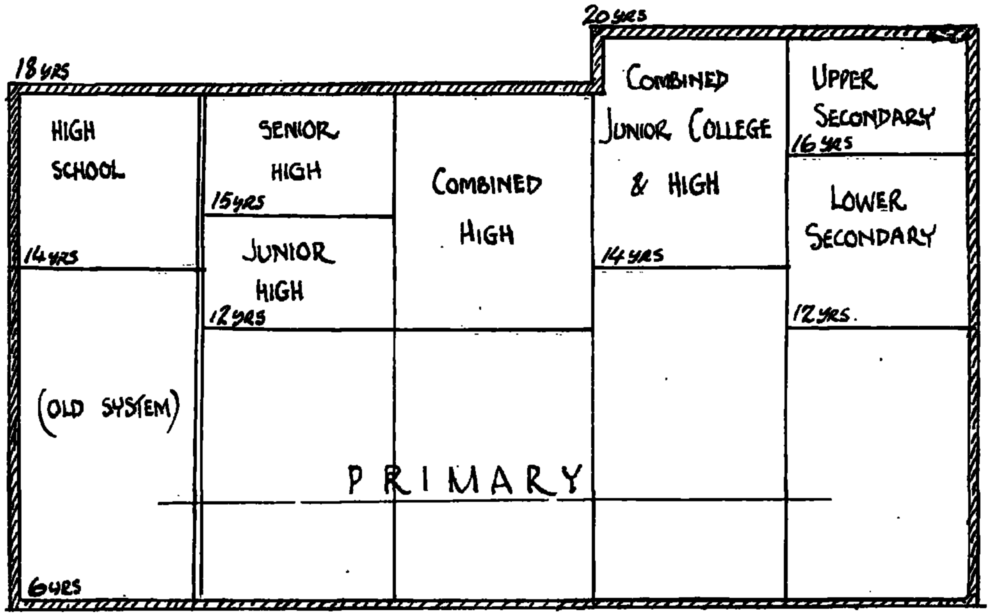
A careful physiological analysis of the thirteen sub tests which make up the Iowa Revision of the Brace test for Junior High School boys and girls was then made.

In the American educational system there are several groupings of schools, the easiest way of showing these is by the following table:



ONE-FOOT-TOUCH-HEAD-TEST

STARTING POSITION.



THE AMERICAN EDUCATIONAL SYSTEM

The Junior High School takes in its intake at twelve plus, which is, of course, one year after our own. Nevertheless it was felt that the Junior High Test would be more appropriate to the British eleven plus sample than the Elementary School Test, particularly as all the items which primarily demanded strength had been taken out of the original Brace test by McCloy in making his revision, and in view of the present deliberations of the Plowden Committee on transfer to Secondary Education at twelve plus.

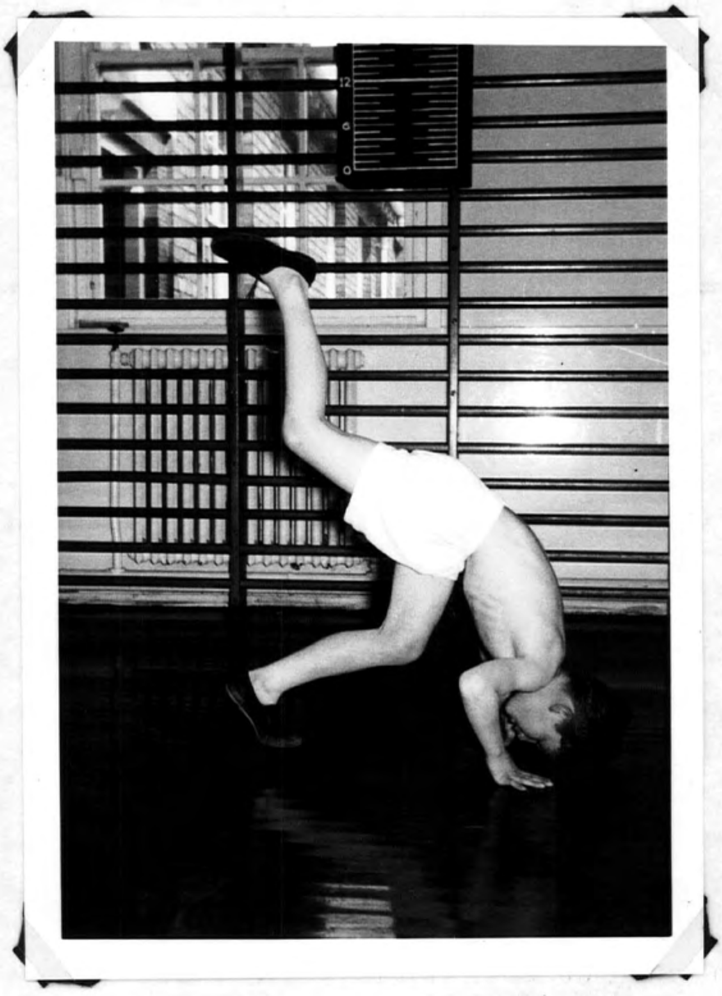
The test items have been grouped into three parts,

(A) those which are common to both boys and girls test batteries.

(B) those which are in the boys test battery only

(C) those which are in the girls test battery only.

The numbers in brackets represent the original Brace item numbers.



ONE · FOOT · TOUCH · HEAD · TEST

A. Items common to both boys and girls tests.

No. 1. (13)

One-foot-touch-head test.

Stand on left foot. Bend trunk forward, and place both hands on the floor. Raise right leg, and extend it backward. Touch head to the floor, and return to the standing position without losing the balance.

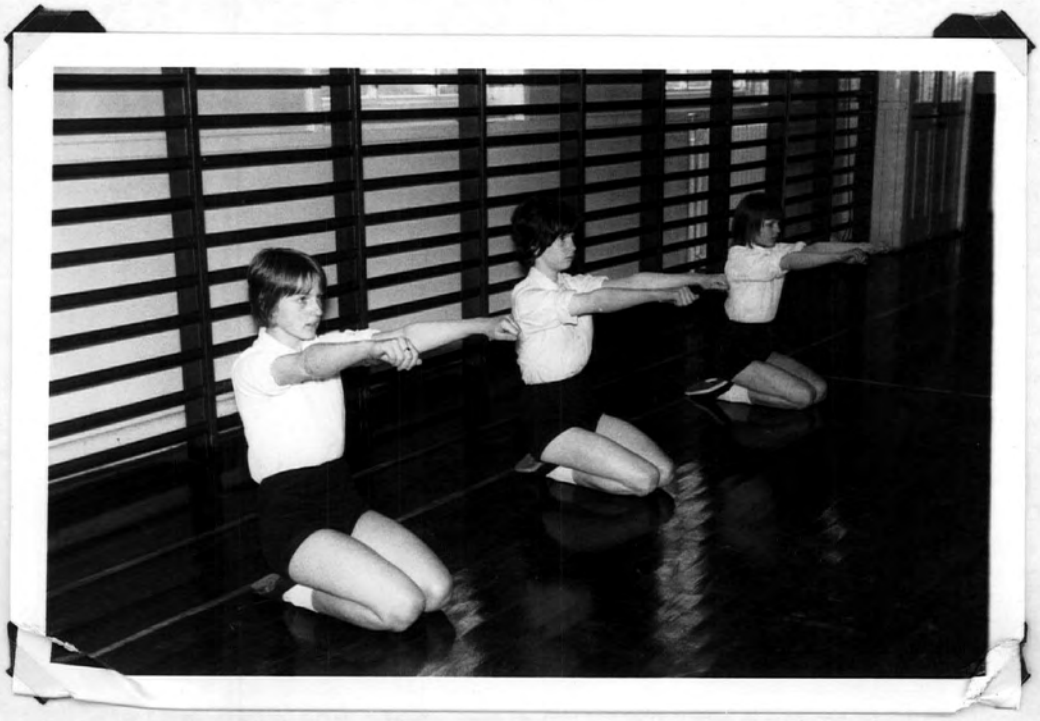
Failure: (a) not to touch head to the floor; (b) to lose the balance.

Particular strength is necessary in the shoulder joint and the shoulder girdle, especially the pro--tractors working eccentrically, this is because most of the body weight is brought forward onto the shoulders as the movement is carried out. The left leg takes the weight throughout the movement but the main work is in the smooth co-ordination between shoulder and leg movement to maintain balance which is of the "Vertical semi-circular canal" type.

Factors involved: (1) Co-ordination

(2) Balance

(3) Arm Strength



KNEEL JUMP TO FEET TEST.

No. 2. (16)

Kneel-jump-to-feet test.

Kneel on both knees. Rest back of toes on the floor. Swing arms, and jump to the standing position. Do not rock backward on toes, or lose the balance.

Failure: (a) to curl toes and to rock backward on them; (b) not to execute the jump, and not to stand still after the standing position has been reached.

The main difficulty is the awkwardness of the movement from the kneeling position, because of this there is a natural tendency to sway back--wards. This has to be compensated for by an extra quick push up movement using strong con--traction of the flexors of the toes, ankles and quadriceps, and extension of the hip. The move--ments of the arms apparently do not either hinder or help the movement except in retaining the balance after the jump.

Factors involved: (1) Power in leg action

(2) A measure of arm control

(3) Insight into nature of movement

SIDE - LEANING - REST TEST

START POSITION

TEST POSITION

<u>No. 3.</u> (<u>21</u>)

<u>Side-leaning-rest test.</u>

Sit on the floor, with lower legs extended, and feet together. Put right hand on the floor behind body. Turn to the right, and take a side leaning-rest position, resting the body on right hand and right foot. Raise left arm and left leg, and hold this position for five counts.

Failure: (a) not to take the proper position; (b) not to hold the position for five counts.

Initially an upward push is necessary to start the movement, therefore the strength of the upward rotators of the scapula and elevators of the shoulder joint are needed. When the desired position is reached, co-ordination of the trunk muscles is necessary to maintain it, especially static work for the right side flexors, lumbar dorsal spine, abduction muscles of the same hip and left adductor muscles of the hip.

<u>Factors involved</u>: (1) A strong balance exercise

(2) Co-ordination

(3) Arm and shoulder strength

FULL-SQUAT-ARM-CIRCLE TEST

START POSITION.

POSITIONS DURING MOVEMENT.

<u>No. 4</u>. (<u>26</u>)

<u>Full-squat-arm-circles test</u>.

Take a full-squat position, with arms raised sideways to the level of shoulders. Wave arms so that each hand makes a circle of about one foot in diameter, and at the same time jiggle body up and down. Continue the performance for ten counts.

Failure: (a) to move feet; (b) to lose the balance; (c) to touch the floor with any other part of body than feet; (d) not to move hands in a circle; (e) not to jiggle up and down.

The starting position is quite easy to take up, but once the activity starts the superimposed movements of the arms and the body tend to disturb the balance, therefore the muscles of the ankle and foot have to work strongly in co-ordination to maintain the position. The quadriceps are in continuous dynamic use for the whole ten counts.

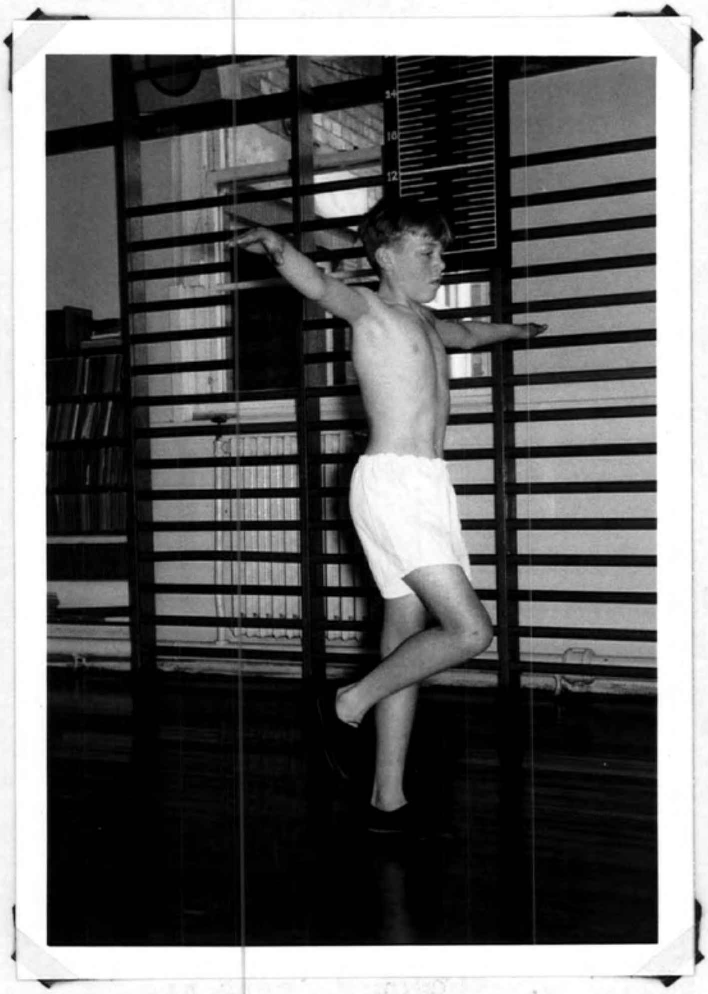
<u>Factors involved</u>: (1) Strength of legs

(2) Co-ordination

(3) Balance

(4) Insight into nature of movement.

(5) Arm Control



HALF-TURN-JUMP- LEFT-FOOT TEST

(START POSITION)

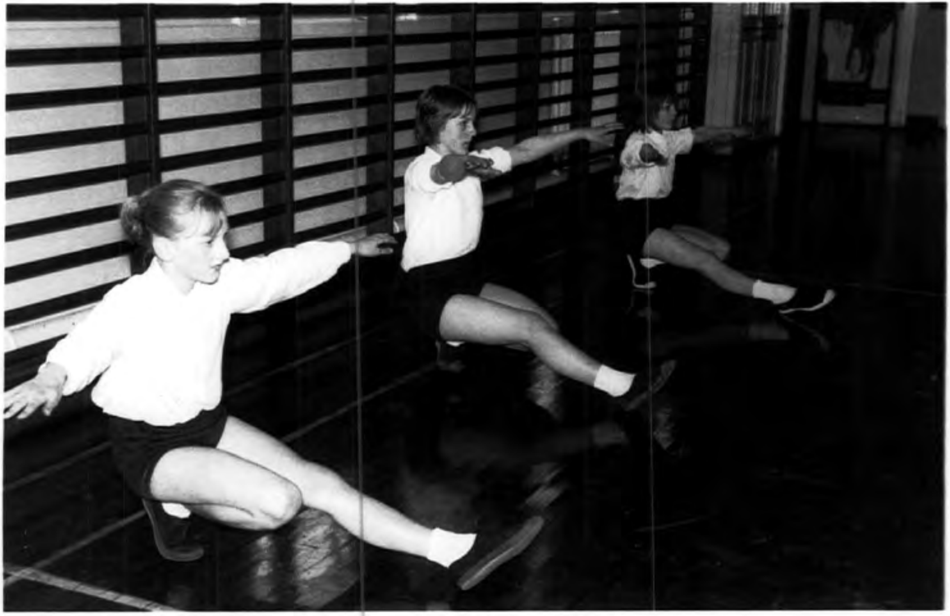
No. 5. (27)

H alf-turn-jump-left-foot test.

Stand on left foot, and jumping, make a one-half turn to the left. Keep the balance.
Failure: (a) to lose the balance; (b) to fail to complete the half turn; (c) to touch the floor with right foot.

An easy exercise mostly concerned with balance. The initial thrust is gained from the left trunk rotators breaking concentrically to start the half turn.

Factors involved: (1) Balance - horizontal semi-circular canals.



No. 6. (29)

Russian-dance step test.

Squat. Raise one leg forward. Perform a Russian-dance step by extending legs alternately while in a squat position. Perform four such steps, that is, two with each leg. Heel of forward foot may touch the floor. Heel of rear foot should strike hip on that side.

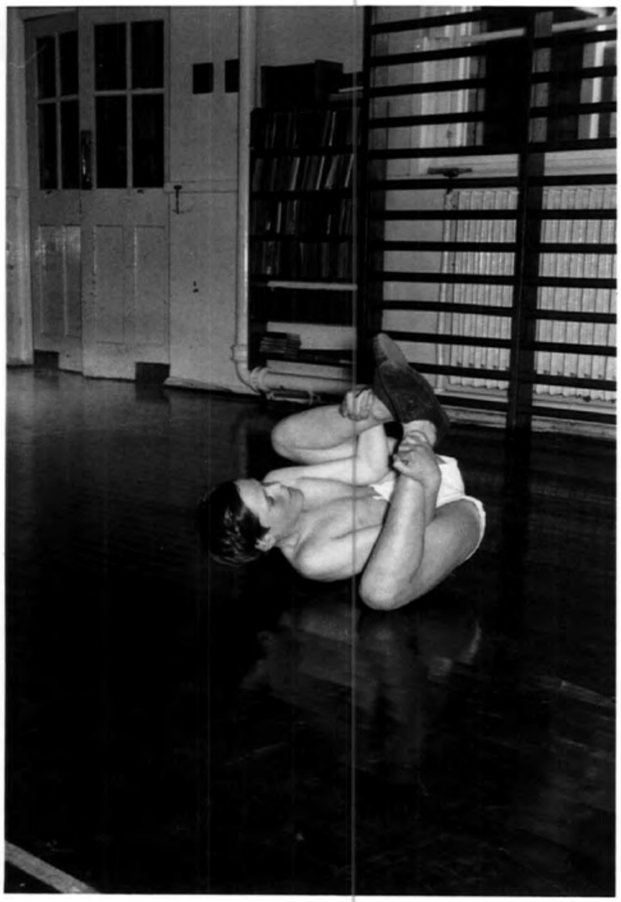
Failure: (a) to lose the balance; (b) not to do the stunt twice with each leg.

Very strenuous indeed for the quadriceps. A difficult exercise for a child who is carrying excess weight. The exercise is mainly one of co-ordination to keep the balance throughout the movement although perfect co-ordination without the strength to do the movement is useless. A combination of strength and co-ordination.

Factors involved: (1) Power in leg action

(2) Co-ordination

(3) Insight into nature of movement.



TOP TEST

(THE ROLL IN PROGRESS)

No. 7. (30)

Top test.

Sit, with lower legs flexed, on the floor. Put arms between legs, and under and behind knees, and grasp ankles. Roll rapidly around to the right, with the weight first over right knee, then over right shoulder, then on back, then on left shoulder, and then on left knee. Sit up, facing in the opposite direction from which the test was started. Repeat the movements from this position, and finish facing in the same direction from which the test was started.

Failure: (a) to release the hold of ankles; (b) not to complete the circle.

Quite an easy exercise physically, but quite a difficult one in coordination and rhythm. Initially full flexion of the lumbar and dorsal muscle groups and hip and knee joints is necessary, then the roll--ing position has to be maintained whilst grasping the ankles. A smooth coordinate movement is necessary throughout to roll from one position to another.

Factors Involved: (1) Co-ordination

(2) Insight into nature of movement

THREE DIP TEST - Start Position.

THREE DIP TEST -

B. Items in Boys Test Only.

No. 8. (5)

Three-dip test.

Take a front leaning-rest position. Bend arms, touching chest to the floor, and push body up again until forearms are in a straight line with upper arms. Execute three performances in succession. Do not touch the floor with legs or abdomen.

Failure: (a) not to push body up three times; (b) not to touch chest to the floor; (c) to touch the floor with any part of body other than hands, feet, and chest.

A strong exercise for the protractors of the shoulder joint and extensors of the elbow. Static work for all the muscles of the spine and the extensors of the hips and knees. Not in this form a difficult exercise.

Factors Involved: (1) Arm strength
(2) Co-ordination

DOUBLE · HEEL · CLICK TEST

No. 9. (8)

Double-heel-click test.

Jump upward, clap feet together twice, and land with feet apart (any distance).

Failure: (a) not to clap feet together twice, (b) to land with feet touching each other.

Somewhat similar to side kick test (28). A powerful take off is necessary to give time for the double heel click superimposed on the original jump. Strong exercise for the extensors of the hip and knee and the plantar flexors of the ankle. Co-ordination of the trunk and leg muscles is necessary to ensure a good landing.

Factors Involved: (1) Co-ordination

(2) Power in leg action

(3) Insight into nature of movement

GRAPEVINE TEST

No. 10. (14)

Grapevine test.

Stand with heels together. Bend trunk forward, extend both arms down between legs and behind ankles, and hold fingers of hands together in front of ankles. Hold this position for five seconds.

Failure: (a) to lose the balance; (b) not to hold fingers of both hands together; (c) not to hold the position for five seconds.

A difficult position to obtain, but a simple and straightforward test of balance, made into a very critical one by the narrowness of the base.

Factors involved: (1) Balance

(2) Flexibility

FORWARD - HAND - KICK - TEST

C. Items in Girls test Only.

No. 11. (25)

Forward-hand-kick test.

Jump upward, swinging legs forward. Bend trunk forward, and touch toes with both hands before landing. Keep lower legs in as straight a line as possible with upper legs.

Failure: (a) not to touch toes with both hands before landing; (b) to bend lower legs more than forty-five degrees.

Initially for this movement a strong contract--ion of the quadriceps and the plantar flexors of the ankle is needed. Co-ordination of the flexors of the lumbar, dorsal spine to take up fully the contracted position when in flight is important, but the movement does not require strength in these muscle groups. The demanded failure for bending the legs more than forty-five degrees seems a little hard.

Factors Involved: (1) Power in leg action

(2) Co-ordination

(3) Insight into nature of movement

<u>No. 12.</u> (<u>28</u>)

<u>Side-kick test.</u>

Swing left leg sideways to the left, jumping upward with right leg. Strike feet together in the air, and land with feet apart. Feet should strike together in a line that would go to the left of left shoulder.

Failure: (a) not to swing leg enough to the side; (b) not to strike feet together in the air, to the left of the line of left shoulder; (c) not to land with feet apart.

Rather similar to (8). The actual side kick is not in itself difficult providing the performer obtains a good firm take off. The real difficulty is in the landing when failure to correct the position of the centre of gravity occurs. The exercise is not particularly strenuous.

Factors Involved: (1) Power in leg action
(2) Co-ordination

No. 13. (31)

Single-squat-balance test.

Squat on either foot. With hands on hips, raise one leg forward. Hold this position for five counts.

Failure: (a) to remove hands from hips; (b) to touch the floor with raised leg; (c) not to hold the balance for five seconds.

Assuming the squat position is not difficult. The superimposed movement is simple, mechanically, to carry out, providing a good static co-ordination of the supporting leg, extension of the hip, flexion of the knee, plantar flexion of the ankle and long flexors of the toes are obtained. The complexity of co-ordination makes this a very good test of balance.

Factors Involved: (1) Co-ordination

(2) Balance

One of the fascinating features of this field of research is that both physiological and statistical analyses can be made. The physiological analysis made by the author shows seven main factors:

(1) Co-ordination
(2) Balance
(3) Insight into nature of skill
(4) Power in which speed of muscular contraction is more important than strength
(5) Flexibility
(6) Leg Strength
(7) Arm Strength

When Cope (74) in 1938 made a statistical study of the component factors of the Iowa Brace test, her factorial analysis established the following six factors:

(1) Dynamic Energy
(2) Flexibility
(3) Balance
(4) Semi-circular canal balance
(5) Insight into nature of the skill
(6) Arm Control

By dynamic energy Cope meant a factor which involved the differences in the speed with which persons who (say) were able to lift the same weight could throw this strength into action. Obviously this is somewhat similar to the definition of power used in the author's factor (4). Flexibility or the range of movement possible at the various joints is a standard definition and is the same in both analyses. There are two facets of balance. The author presumes that Cope's factor three is the same as his own factor two and means the ease with which body balance is maintained, for instance in a hand stand. Cope's factor four, semi-circular canal balance, can itself be split into two sections, (a) Vertical and (b) horizontal. Vertical semi-circular canal balance is the contribution to balance made by the two vertical sets of semi-circular canals which seem to function together primarily in forward, backward and sideways movements. Horizontal semi-circular canal balance is the contribution to balance made by the canals when the head rotates around a vertical axis or in the plane of the horizon--tal canals themselves. It is assumed that Cope's factor four indicates the presence of both.

"A person who is most aware of the nature of the skill that he is trying to learn learns the skill most rapidly", says Cope, she apparently based her factor five on a previous study by Combs which the author has been unable to obtain. As McCloy (8) also included this factor in his factors of motor educab--ility the author admits that he was searching for it from the start of his physiological analysis, though he maintains that as only two attempts are allowed at the items without previous practice, its inclusion can readily be justified. Arm control, Cope's factor six, is related to her factor five and would appear to involve a matter of balancing the action of a gross motor movement by the use of the reaction of the arms.

The factors which showed up most prominently in the author's analysis were:-

(1) Co-ordination
(2) Balance
(3) Insight into the nature of the skill
(4) Power, in which speed was more important than strength

It will be recalled that at the beginning of the present chapter in presenting his six factors of gross motor ability to be measured, the author included balance in his factor of co-ordination. Insight into the nature of the skill was also included as a factor of motor educability. From the evidence of past research, these analyses and his own experience the author decided to use the Iowa Brace items as measures of the factors of motor educability and co-ordination. As the try out showed that a normal sized class could be tested in a period of thirty five minutes this part of the proposed test became test battery Number One. In view of the fact that the table of activities from standard works (Page 75) indicates that some 37% of the activities and skills regularly used in physical education syllabuses have heavy loadings of the two factors, the time spent in testing them was not considered excessive.

(d) The Construction of Test Battery Number Two.

Attention was now turned to the four factors for which tests had still to be devised or chosen. It was not anticipated that there would be much difficulty in finding test items which would measure these factors as many activities in the physical education programmes readily lend themselves to this purpose, many in fact having been previously used in this way. The main problems were thought to be finding the best ones for the particular purpose with which the present study is concerned, and their inclusion in the correct proportions, remembering that it is almost impossible in this field to find pure measures of any one factor due to the well established overlapping of factors. In looking through the possible test items which the author had accumulated over several years, the following considerations were born in mind in choosing thirty one items for a preliminary try out:-

1. The items should be easily administered with no possibility of confusion or misunderstanding of their requirements, or possibility of injury to any child.

2. As battery Number 2 was meant to be finally administered in one period, items must be of short duration.

3. As the factors to be measured included strength, endurance and power, care had to be taken that test items were not of an exhausting character so that fatigue did not influence the test situation.

4. The apparatus available in schools being so varied, the less apparatus necessary for any test item the better.

5. If possible test items should measure a wide variance in degree of achievement.

6. Past researchers have noted that test results of some aspects of physical activity, particularly of strength, do not produce a normal distribution.

7. Stafford (84) demonstrated that although the use of a large battery would raise the validity of a test, consideration must be given to the purpose of the test to ensure that the increase gained warrants the extra time necessary to administer the larger test.

8. Making an analytical study of sex differences as they affect the programme of physical education, Moore (85) demonstrated that throughout the school age the male has a higher metabolic

rate than the female. His measurements also showed that girls' shoulder width is relatively narrower, lung capacity smaller, and centre of gravity lower. He concluded:

> "It must be remembered that girls are not physically so well equipped to perform vaulting and hanging activities on pieces of apparatus as boys, but there is a drastic need for the development of the muscles used in such activities".

The thirty one items were tried out with the same sample as that used for the Iowa Brace try out. Several of the tests were immediately discarded owing to them being found to be (a) too difficult, (b) too time consuming, or (c) requiring too much space.

Examples of discarded tests:-

(1) The squat thrust test. This is a well established movement, which has been included in many physical test batteries. It measures accurately nimbleness of foot and the ability to change direction of movement quickly. Many boys and girls of this age group found the test very difficult to grasp, particularly those in the educationally sub-normal range, even when taught the movement step by step.

This item was eliminated on counts (a) and (b) above.

(2) Standing pull up on the beam. It was realized from a study of past research that a pull up test on the beam in which the movement is started with the feet clear of the floor was not likely to give the variance of performance necessary, so the movement was tried from a standing position with arms at

full stretch. It proved both too difficult and also too time consuming as the beam had to be adjusted for each performer.
(3) A form of maze run consisting of seven chairs set out in a pre arranged pattern seemed promising for measuring speed and the ability to change direction, but it was discarded because it required too much space and because of administrative difficulties.

Finally six items were chosen which seemed to the author to measure the desired factors. These items were of a nature which would allow a normal sized class to be tested in a manner similar to the group work system of the normal physical education lesson, that is the class would be split into six groups and the groups would then move round the gymnasium to face each test situation in turn.

SPEED TEST (a) Start position

(b) The return

Description and Analysis of the Items in Test Battery Number Two.

1. Speed Test.

Apparatus required, eight bean bags, stop watch and marked out course.

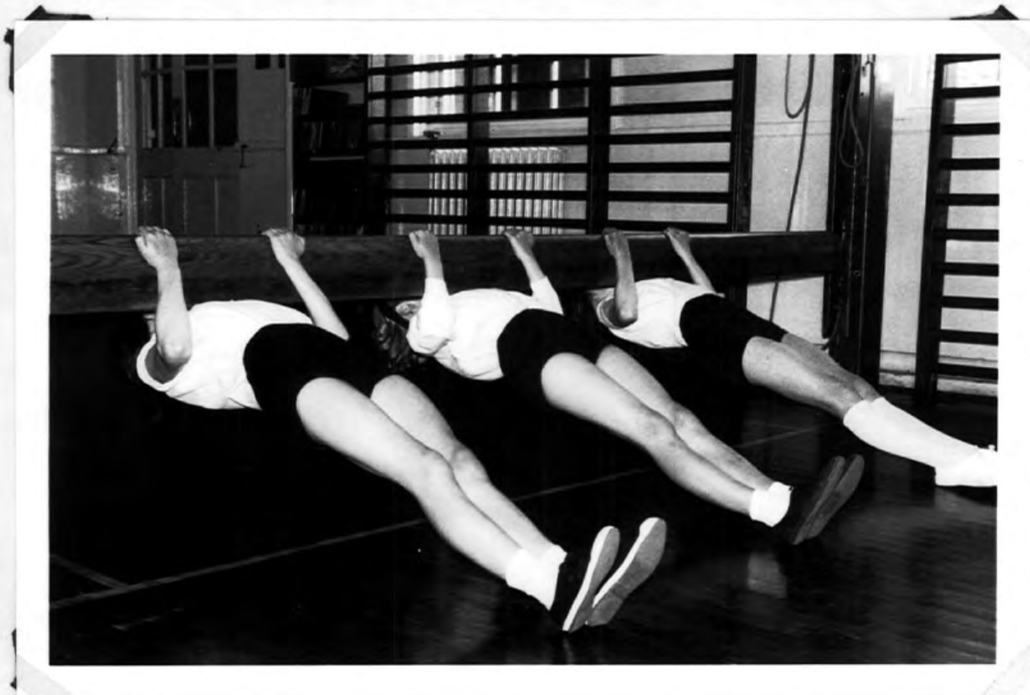
Start line	1.	2.	3.	4.	5.	6.	7.	8.
	•	•	•	•	•	•	•	•

The interval between the start line and the first bean bag is five feet. Each succeeding bean bag is set five feet from the preceeding one in the manner shown.

The performer starts with both feet behind the line. On command "go" the stop watch is started and pupil moves to pick up bean bag 1, returning to drop it over line before starting back again to pick up No.2, and so on. Note: It is essential that each time he returns to start line one foot must be placed over the line before return run begins. On return with No, 8 the watch is stopped and time recorded to the nearest one fifth second.

The test was found to be easy to perform from all points of view. It calls for accuracy in foot placing and speed in turning. There is strong muscle work for the plantar flexors of the ankle and the extensors of the knee and hip in thrusting the body forward. The same muscle groups are also involved in the deceleration. Both boys and girls enjoyed the test and clamoured for more tries to beat their previous best performance, even when they knew that the tests had been completed.

THE START POSITION.



PULL-UP TEST

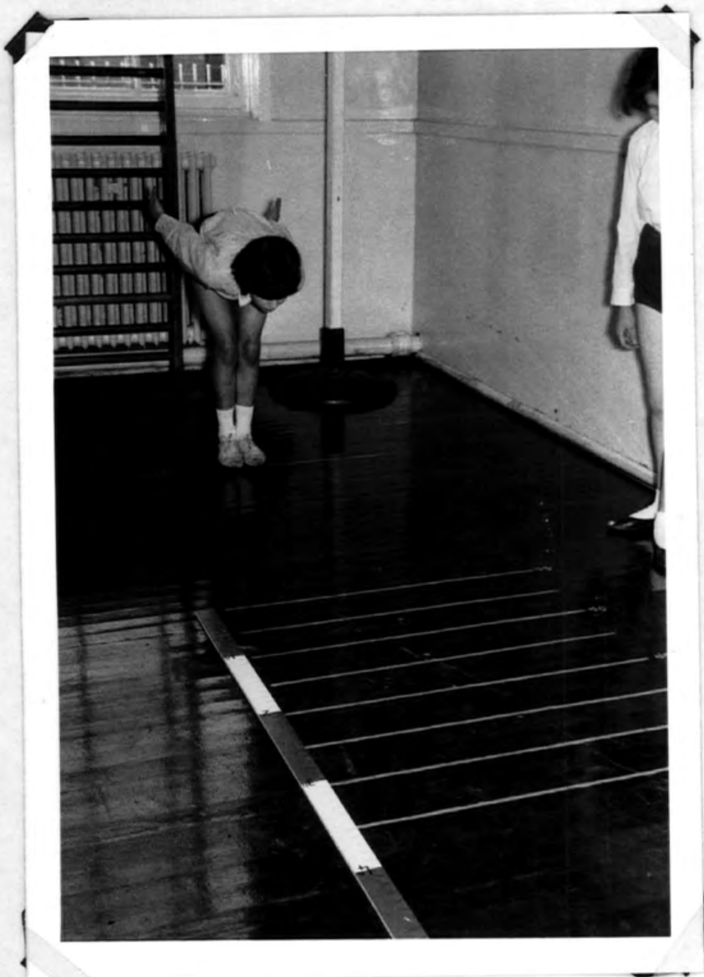
2. Pull-Up Test.

Apparatus required; Beam. In schools where beams were not available, it was found that a bar placed at the appropriate height across two chairs and weighted down by two pupils was an efficient substitute.

The performer lies on back, grasping a beam placed with its top surface 24" above the floor, undergrasp with shoulders 3" behind the beam. Performer then flexes his elbows and keeping his body straight raises his chest to touch the beam. He then stretches his arms and returns to back lying. Without pause the movement is repeated rhythmically as often as possible. If form is lost (i.e. body sags or chest is not brought up to beam) the test is concluded. Score is recorded as number of pull-ups done whilst maintaining form.

It is much easier to do this movement with undergrasp because the wrist, elbow and shoulder are performing flexion which is a very natural movement and facilitates a fixation point for the muscles which raise the trunk (i.e. latissumus dorsi and pectoralis major). Whilst the arms are raising the chest, the muscles of the rest of the body are working statically to maintain the straight line of the body. This movement is a classical form of the third order of leverage where the fulcrum is far removed from the source of power. It follows that the extensors of the hip in particular, helped by the plantar flexors of the ankle, work concentrically to push the feet down onto the floor.

In the preliminary try out both the undergrasp and



THE STANDING BROAD JUMP

(a) Start position

(b) The measuring apparatus

overgrasp starting positions were tried. It was found that the undergrasp position seemed to give a better spread of results. This is because with the overgrasp the elbows tend to poke out sideways and the arms have to work much harder to fix the origin of the latissimus dorsi and pectoralis major. In addition the muscles of the spine have to work concentrically to extend the spine in order to bring the chest to touch the beam. There is an apparent greater distance to travel with overgrasp as opposed to undergrasp.

3. Standing Broad Jump.

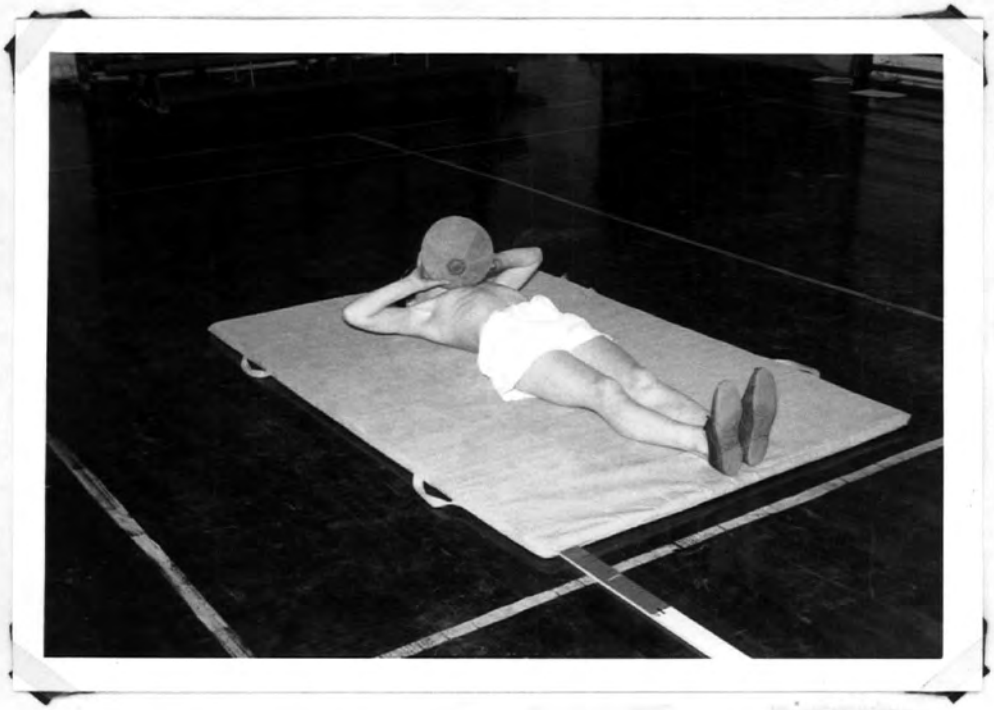
Apparatus required, Start line on the gymnasium floor, tape measure and large "T" square to accurately measure the distance jumped.

The performer toes the start line, bends body forward and with legs bent at an angle of about ninety degrees swings the arms forward to gain momentum for the jump, which after execution is measured in the way usual in long jumping.

Distance is measured to the nearest half inch.

An easy to perform and enjoyable test, particularly well done by the thin agile child. There is strong muscle work for the plantar flexors of the ankle and the extensors of the hip and knee. Position in flight and on landing is important and some coaching is necessary before the test is attempted.

Zimmerman (86) in 1956 in studying the standard form of this test stated that it had long been considered a fundamental human activity, and had been included in various forms in the



(a) Start Position

MEDICINE BALL THRUST

(b) Sitting position

test batteries of Cureton, Rogers, Brace and Scott. Zimmerman used the method of Cinematographic Analysis to show three phases: (1) application of force for take off

(2) projection of body upward and forward

(3) descent occurring after gravity has overcome the vertical component of force.

Results showed that movement patterns in skilled and non-skilled performances were similar, but before take off the skilled used greater amounts of ankle flexion and of hip, knee and ankle extension, than did the non skilled. Kane and Meredith (87) measuring the ability of a large sample of American boys and girls in this activity took great pains in all respects to see that the tests were carefully carried out. They demonstrated that starting without practice the performance of the children continued to improve until about the ninth to the twelfth attempt.

The general conclusions were that:

(a) Size and shape have an influence on performance

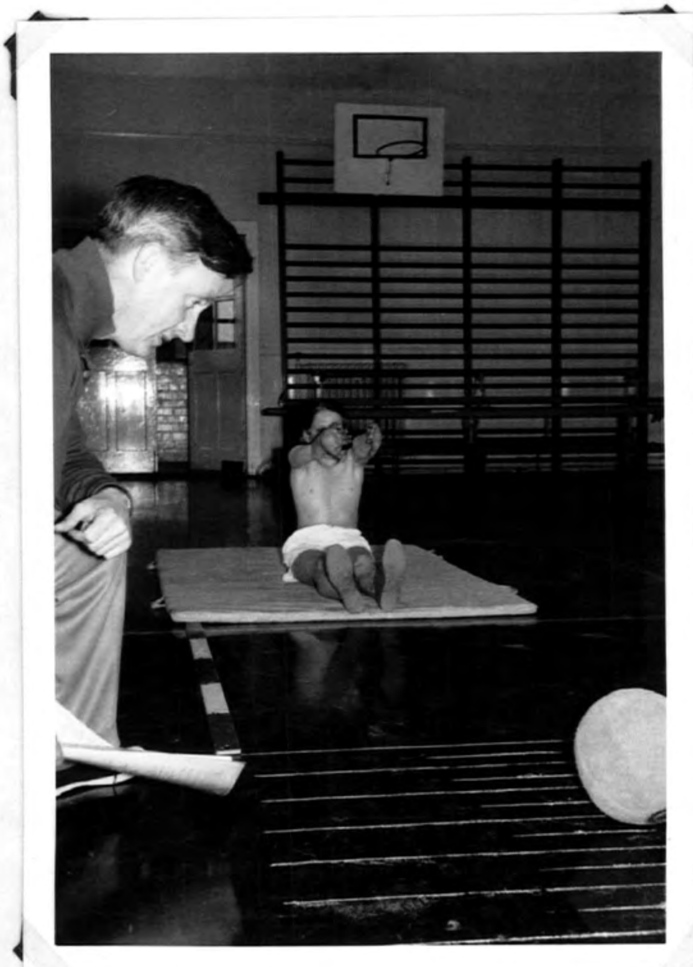
(b) The thin and medium in physique perform well

(c) The very obese are worst.

4. Medicine Ball Thrust.

Apparatus required, 5 lb. medicine balls, measuring apparatus similar to that used in test 3.

The performer starts in the back lying position on a mat with his heels on the start line, holding the medicine ball to his chest equally with both hands, (as in basketball push throw).



(c) The throw.

The aim is to swing the trunk upwards and forwards and push the ball at an angle of elevation of about forty five degrees in the air along the previously marked course. If the performer is unable, after practice, to perform the movement well, a sitting throw is allowed with as much body swing as the performer wishes. McHone (68) successfully allowed a choice of starting position in a somewhat similar test item when measuring the physical efficiency of High School boys in 1952. The throw is measured to the nearest inch.

There is strong abdominal work, especially for the rectus working concentrically in its full range to raise the trunk followed by rapid combined extension of the elbow and wrist, and flexion of the shoulder to give the "explosive" movement necessary. The extensors of the leg and hip work statically to keep the legs in contact with the floor. This thrusting activity is at first usually more easily performed in the long sitting position, but it was interesting to find that, with the preliminary practice allowed to gain style, in many cases greater distances were achieved from the lying position. This is because of the extra leverage gained with the bigger arch of movement. The author thought during the experiment that a lighter medicine ball would have to be introduced, especially for girls, but it was found that a sufficient range of scores could be obtained with the 5 lb. ball and the limited distances thrown helped in the safety factor. A light coating of powdered french chalk on the ball helped in determining the correct measuring point on some floors.

JUMP REACH

(a) The preliminary swing

5. Jump Reach.

Apparatus required; some form of measuring instrument, graduated in inches. A measuring board for hooking over wall bars or suspending on hooks to a wall was designed by the author, (see photograph on opposite page). The board is fixed so that the smallest member of the sample can comfortably reach the scoring area with an upstretched hand without jumping. A sheet of heavy paper, or a blackboard, marked in inches, con--tinuing for five feet, includes all jump possibilities and can be used instead if set in an appropriate position against a wall. The marking of each foot should be continued further that the others, and marked in a different colour for easy identification.

(a) The performer stands sideways to the measuring instrument, with one shoulder almost against the wall, feet firmly on the ground and raises the arm nearest the board to the vertical position, (as shown in photograph). The height of the index finger on the board is measured.

(b) Standing in the same position the performer bends his legs and using a vigorous forward and upward swing of the arms jumps upwards as high as possible, touching the board with his wet (or chalked) index finger. The distance between the two measurements is the height jumped, and can easily be assessed to the nearest half-inch.

Jumping upwards from one or both legs always calls for a strong combined concentric effort of the plantar flexors of the ankle and the knee and hip extensors. The extensors of the spine combined with full elevation of the shoulder undoubtedly help

(b) The Jump.

with the upward thrust. The existence of a target enables a greater height to be achieved owing to the establishment of maximum motivation.

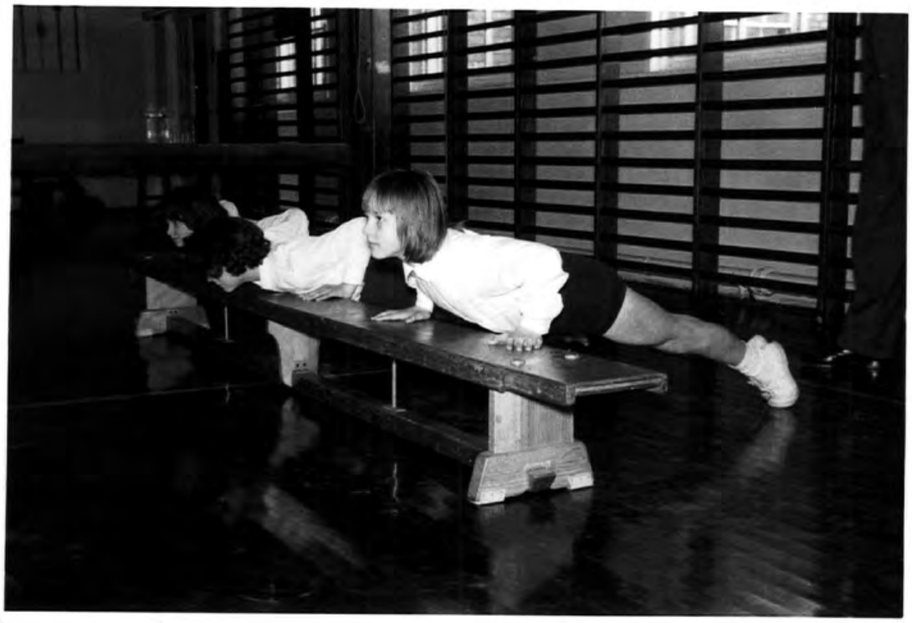
This type of test in different forms has a long history since Sargent first introduced his version in 1921. McCloy (88) reporting on recent studies in 1932 found a high correlation between test results and athletic events (r = 0.752). He concluded that the Sargent Jump when practised and correctly administered was undoubtedly a valuable test. Carpenter (89) using the test in studying the effective strength of college women found a correlation of 0.5267 between the test and her criterion. She felt that this demonstrated a positive correl--ation between power and athletic performance. Reliability coefficients reported for the test in the period before the Second World War by several researchers varied between 0.85 to 0.96.

6. Press Ups.

Apparatus; used for girls only, gymnastic benches.

Boys: The performer places his hands on the floor and assumes the well known position, body and arms straight with hands vertically under the shoulder. The arms are then bent so that the chest touches the floor and the arms are then straightened to lift up the body to its starting position. Performers are warned not to touch the floor with legs and/or waist, and that the body must be straight. The movement is repeated as often as possible. The test ends when the body sags or lower trunk

BENCH PRESS-UPS



(a) The bent arm position ~ note lovely position of the girl on right of picture.

(b) The straight arm position.

touches the floor.

<u>Girls:</u> The test is the same as for boys, except that girls perform the easier movement of placing their hands on the face of a gymnastic bench, (see photographs). Obviously the waist cannot in this test touch the floor but body sag will still take place.

Abdominal muscles work statically with the flexors of the hip to keep the body straight. The outward rotators of the hips are involved, otherwise the heels would fall apart.

To perform the dipping movement the flexors of the shoulder and extensors of the elbow work eccentrically to lower the chest to the floor. To return to the starting position the same groups work concentrically. The flexors and extensors of the wrist and fingers work strongly through--out the movement.

It was thought from the results of the first try out that this item would have to be made somewhat easier for the girls, and certainly the modification increased the spread of scores to a large degree.

Scoring: Each completed movement counts one point. If the performer does not go the whole way down or up, half a point is counted, but the test ends after three consecutive half-points.

The Try Out.

The preliminary try out having revealed sixteen items which seemed to satisfy the author's requirements, instruction sheets containing details of the items of the two test batteries were made up.X The wording of the test item instructions was carefully revised to remove several ambiguities which had become evident. The author also consulted his colleagues who had taken part in the preliminary try out of the test and found their impressions and comments valuable. The sample was care--fully chosen to include boys and girls from all types of secondary schools situated in as many parts of the country as possible, and from different localities. The one limiting factor in choosing the sample was that only schools with fully qualified physical education staff personally known to the author were asked to help. Ten secondary modern schools; three from Yorkshire, three from Lancashire, one from each of the following, Essex, Nottinghamshire, Cheshire and Kent, contributed to the sample. Of these two were city schools, four were situated in small inland towns, one in a seaside town, and the remaining three in country districts. Two secondary grammar schools, one from Lancashire and one from Yorkshire, a Yorkshire secondary grammar-technical school, a large Yorkshire comprehen--sive school, and a small school for educationally sub-normal children also helped.

The schools were asked to do two things:-

X See Chapter X, Manual of instructions.

1. To try out the Iowa Brace test without practice and strictly according to the printed instructions with as many boys and girls in the age groups 11+ to 15+ as they reasonably could, scoring each item two points for success in the first trial, one for success in the second trial, having failed first time, and nil for failure in both. The reason for the inclusion of all pupils within the statutory age limits was that the author considered this a good opportunity to check American standard scores on the Iowa Brace test using a British sample, so that a statistical comparison could later be made. Eight hundred and twenty four boys and one thousand one hundred and forty eight girls made up the sample.

2. To try out the items of Battery Number Two, after giving the amount of practice they considered necessary for the efficient execution of the tests, by scoring four consecutive trials for each test. The sample in this case to consist of all boys and girls in the 11+ age range.

The number of trials necessary to obtain satisfactory results in physical tests is an interesting study in itself, McGraw and Tolbert (90), in their comparison of the reliabilities of methods of scoring tests of physical ability, found that it was doubtful whether single trials or combinations of two trials would produce reliable scores, coefficients of variation tending to be smallest for the "best of three" method. No higher number of trials was however tried in this study.

Kane and Meredith (87) used twelve trials, apparently without previous practice. In their sample 25% attained maximum distance in a jumping test in one of the first four trials, whilst 40% made their best jumps between the ninth and twelfth jumps. Glover (5) also found that in some tests members of his sample reached a maximum as late as the sixteenth and seventeenth trials and he continued his measurement "until three successive declining scores showed that the jumper had passed his peak". Both Steel (92) in 1952 and Clark (93) in 1960 demonstrated that even mental practice of a physical skill was almost as effective as physical practice. The author decided, in view of this evidence, and also to keep the work he was asking his colleagues to do to a reasonable amount, that after previous practice considered by the tester to be sufficient, the best of four recorded scores would at this stage give a reasonably true representation of the merit of the performer.

This large scale try out involved a total of seven hundred and twenty nine boys and five hundred and forty one girls, although not all the pupils in the sample did all the tests. The try out took place during the first two terms of the school year 1962/3, and its main aims were:-

(1) To produce statistical evidence which would help in the formation of a final balanced test battery.

(2) To examine the Iowa Brace scores of a British sample statistically, and to check these against the recorded scores of American samples by working out T scores.

(3) To find the range of scores produced by the items of Battery Number Two and from these evolve a scoring system, devising new scoring techniques, or adapting old ones where necessary.

An auxiliary experiment with the Iowa Brace Test.

During the same period of time that the try out began, an auxiliary experiment was also begun concerning the validity of the Iowa Brace test as a measure of motor educability. The review of past research revealed that various researchers in America had come to differing conclusions regarding the value of the tests as a measure of motor educability, and in reaching these conclusions a variety of criteria had been used. McCloy (38) used attainment at the time of testing in athletic events and tumbling; Hoskins (91) used the participation of students in various sporting activities; Brace (39) himself used the learning of rhythms and sports skills; Gire and Espenschade (42) used the rate at which their sample learned new skills or relearned old ones in basketball, volleyball or baseball. Henry and Nelson, in a general study of learning, pointed out the futility of trying to measure the ability to learn by studying performance level; they stated that learning ability must be tested directly. Henry evolved a method of measuring motor learning by equating his subjects statistically and then calcul--ating how much the individual learner had improved, the relative degree of improvement representing the learning rate.

Having the good luck to find a secondary school where the intake was entirely from one adjoining junior school where no indoor physical education was taught, the author formed a class of thirty six boys and girls who volunteered to stay behind for two separate hours each week ostensibly to practise gymnastics.

Everyone who volunteered was accepted without reservation and, after one free exploratory session,the Iowa Brace test was given to all the sample and the scores recorded. In the third session eight gymnastic activities were demonstrated and the pupils invited to "have a go". The boys and girls having had neither practice nor instruction,their results were on the whole very poor with one or two notable exceptions. The results were recorded on a five point scale in the usual way [x] by four experienced teachers of physical education, the average of the four marks being taken as the score. The tests were:-

1. Forward and backward roll combined
2. Headspring off box top
3. Handspring
4. Astride vault over buck (3 holes)
5. Long astride vault over box
6. Upward and downward circle on beams
7. Cartwheel to arab spring
8. Hand balance

Care was taken that landings in tests 2, 3, 4 and 5 were well padded and support was at the ready in tests 2, 3, 4, 5 and 7 to prevent accidents to the performers.

For the next six months the classes were held regularly, attendance and enthusiasm were well maintained as there was no pressure and the children thought of the classes entirely as a club activity. Care was taken that each group had the same coaching and the same time to practise each event, although it was impossible to ensure that the same number of trials were essayed in each time allocation. The same four experienced teachers then conducted a second series of tests in the eight

X See "Tests and Measurements in Health and Physical Education" by McCloy and Young. Page 23.

activities, trying their best within subjective limits to ensure that their standards were the same as in the previously held tests. The percentage increases in performance were calculated, these were then correlated with the scores of the Iowa Brace tests by the Product-moment method.

The main aim of this auxiliary study was to indicate whether the Iowa Brace items were together an efficient predictor of motor educability within the chosen field of study, as past research makes it clear that no test yet evolved has been successful in predicting general motor educability.

The experiment was repeated during the 1963/4 school year with a different sample, consisting this time of thirty-two boys and girls. The same four examiners were fortunately still available and the method therefore differed very little from the one used in the previous year. At the same time, in another school, a colleague carried out a somewhat similar experiment with two classes of boys, one consisting of thirty seven boys and the other of twenty six boys, all being in the 11+ age group. The nature of the experiment limits the size of each individual sample to below forty as physical education classes rarely exceed this number for a host of well known professional, technical and physical reasons. It is claimed however that conditions were so similar for the two mixed groups, and again for the two boys' groups, that two larger samples could justifiably be formed, one from each school, to assist in arriving at some of the statistical conclusions.

The technique of measuring improvement in performance was the same in each case, the sum of the first eight scores being taken from the sum of the second eight, the result being divided by the possible score and the whole expressed as a percentage.

$$I = \frac{5}{2}(S2 - S1)$$

where I = Percentage improvement

S2 = Score on second test battery

S1 = Score on first test battery

It is fully realized that the size of the two samples (a total of 68 in the mixed group and 63 in the boys' group) makes the experiment only a check on the American researches, although some American researchers have drawn generally accepted conclus--ions from samples very little larger than these. The results of this auxiliary experiment are tabulated in Chapter VII (pages 143 and 144).

CHAPTER VII

THE STATISTICS OF PHASE ONE

TABLE ONE

BOYS - RAW SCORES ON THE IOWA BRACE ITEMS - N = 824

SCHOOL

SCORE	A	D	E	F	J	K	L	M	N	TOTALS
20		8		2	2	6		1	1	20
19	1	11	3	4	4	6			4	33
18	2	21	4	4	12	10		4	5	62
17	6	17		12	23	7			7	72
16	14	22	9	10	18	10		4	5	92
15	17	22	2	9	18	22		1	11	102
14	13	19	6	16	10	19		4	9	96
13	5	19	4	10	18	5		3	3	67
12	13	11	6	9	14	4		1	4	62
11	20	8	8	8	4	13	2	7	3	73
10	11	6	4	5	4	6	1	2	4	43
9	3	3	7	4	3	3	2		2	27
8	8	2	2	3	6	3		1	3	28
7	4	4		2	2	2	2		1	17
6			1	2	1	1	1		1	7
5				2	2	1	1		1	7
4		1	2	1	1	1	1			7
3				1		1	2		1	5
2							1			1
1										0
0							3			3
TOTALS	117	174	58	104	142	120	16	28	65	824

M = 13.676 (± 0.126)
SD = 3.62

TABLE TWO

GIRLS- RAW SCORES ON THE IOWA BRACE ITEMS - N = 1148

SCHOOL

SCORE	A	B	C	D	E	F	G	H	I	TOTALS
20		1	1	6			6	1	2	17
19		4	1	11	1	1	8	2	3	31
18		6	4	15	3	1	11	4	9	53
17	1	15	5	18	1	9	12	2	12	75
16	2	14	4	13	5	6	11	7	15	77
15	3	23	10	28	3	7	10	18	17	119
14	1	20	15	17	5	10	15	16	14	113
13	2	11	8	19	6	5	17	20	12	100
12	5	18	15	16	4	14	12	23	8	115
11	10	6	12	15	8	4	11	14	4	84
10	19	4	11	13	5	10	3	10	11	86
9	22	6	11	2	11	2	10	7	2	73
8	17	2	6	5	6	8	7	8	5	64
7	17		4	2	5	4	3	4	1	40
6	21	3	4	4	5	1	2	3	2	45
5	9		1	3	2	3	2	3	1	24
4	5		1		1	1	1	1	1	11
3	8		1			1		1		11
2	3		1					1		6
1	2									2
0	2									2
TOTAL	149	133	115	188	71	87	141	145	119	1148

M = 12.326 (± 0.116)
SD = 3.93

TABLE THREE

BOYS - SCORES ON EACH ITEM OF IOWA BRACE TEST - N = 824.

SCHOOL	ITEM NUMBER 1	2	3	4	5	6	7	8	9	10	Total possible in each Test	N	Total Scores	Possible Score	% age score on Test
A	182	181	163	113	88	200	188	190	139	44	234	117	1488	2340	63.55
C	321	290	289	310	160	323	286	274	204	129	348	174	2588	3480	74.66
E	110	96	94	51	26	91	81	73	61	29	116	58	712	1160	61.38
F	196	182	189	90	65	174	156	174	91	73	208	104	1390	2080	66.82
J	268	227	233	33	166	262	257	253	192	125	284	142	2016	2840	70.98
K	194	184	213	139	82	214	195	202	148	117	240	120	1688	2400	70.33
L	16	18	10	1	0	16	14	8	4	0	32	16	87	320	27.19
M	55	45	52	10	25	50	51	52	32	11	56	28	383	560	68.39
N	116	108	103	64	56	112	104	100	78	58	130	65	899	1300	69.15
Total Score on each Item	1458	1331	1346	811	668	1442	1332	1326	949	586	1648	824	11251	16480	68.22
FACILITY	88.47	80.76	81.67	49.27	40.17	87.5	80.76	80.46	57.58	35.56	68.22	whole test			

TABLE FOUR

GIRLS - SCORES ON EACH ITEM OF IOWA BRACE TEST - N = 1148

SCHOOL	ITEM NUMBER 1	2	3	4	5	6	7	8	9	10	Total possible in each Test	N	Total Scores	Possible Score	% age score on Test
A	176	180	167	35	80	180	161	88	60	43	298	149	1170	2980	37.91
B	219	232	232	132	188	207	227	133	149	142	266	133	1861	2660	69.92
C	176	173	146	88	95	172	174	131	111	93	230	115	1359	2300	59.09
D	329	318	285	241	271	328	315	228	175	128	376	188	2618	3760	69.93
E	102	65	57	77	53	96	103	77	80	65	142	71	775	1420	54.58
F	153	148	90	77	92	151	160	88	50	37	174	87	1046	1740	60.11
G	245	247	201	174	161	241	244	147	148	111	282	141	1919	2820	68.05
H	211	220	189	171	145	198	216	146	156	109	290	145	1761	2900	60.72
I	202	206	134	169	122	193	216	161	139	104	238	119	1646	2380	69.16
Total score on each Item	1813	1789	1501	1164	1207	1766	1816	1199	1068	832	2296	1148	14,155	22,960	61.65
FACILITY	78.96	77.92	65.37	50.69	52.57	76.92	79.09	52.22	46.52	36.24	61.65 whole test				

TABLE FIVE

BOYS - INDICES OF FACILITY AND DISCRIMINATION OF THE IOWA BRACE ITEMS - N = 824

Index of Discrimination worked out by $\frac{U - L}{N/3}$ method using total score on test as criterion.

Item No.X	Facility	Discrimination
1 (13)	88.47	0.23
2 (5)	80.76	0.51
3 (27)	81.67	0.35
4 (30)	49.27	0.38
5 (8)	40.17	0.53
6 (21)	87.5	0.20
7 (14)	80.76	0.26
8 (26)	80.46	0.32
9 (16)	57.58	0.61
10 (29)	35.56	0.58

X The numbers in brackets are the original Brace Test Numbers, see Ref. No. 8, pages 87 to 90, also table 18, page 91. [Bibliography P.192]

TABLE SIX

GIRLS - INDICES OF FACILITY AND DISCRIMINATION OF THE IOWA BRACE ITEMS - N = 1148

Item No.[X]	Facility	Discrimination
1 (21)	78.96	0.22
2 (26)	77.92	0.23
3 (28)	65.37	0.60
4 (30)	50.69	0.55
5 (29)	52.57	0.58
6 (13)	76.92	0.31
7 (27)	79.09	0.20
8 (25)	52.22	0.64
9 (16)	46.52	0.59
10 (31)	36.24	0.43

X The numbers in brackets are the original Brace Test numbers, see Ref. No. 8, pages 87 to 90, and table 18, page 91. [Bibliography P. 192]

TABLE SEVEN

A COMPARISON OF PERFORMANCE OF THE IOWA BRACE TEST OF AMERICAN AND BRITISH SAMPLES IN THE JUNIOR HIGH SCHOOL RANGE BY MEANS OF "T" SCORES.

	Boys		Girls	
Test Score	American "T" Scores	British "T" Scores	American "T" Scores	British "T" Scores
20	66	73	64	74
19	63	66	61	69
18	60	63	58	65
17	57	59	56	62
16	54	55	53	59
15	51	52	50	56
14	48	49	47	53
13	45	47	45	51
12	42	45	43	49
11	39	42	41	47
10	36	39	39	44
9	34	37	37	42
8	32	35	35	40
7	30	33	32	37
6	28	32	30	35
5	26	30	26	32
4	24	28	-	30
3	22	26	-	28
2	20	23	-	25
1	19	22	-	22
0	-	-	-	-

American "T" Scores from "Tests and Measurements in Health and Physical Education" by McCloy & Young, Table 20 Page 94.

British "T" Scores worked out by the author using similar methods. See Ref. 94 in Bibliography.

TABLE SEVEN (A)

A comparison of the Scores of British Samples of the Eleven Plus Range and of the Full S tatutory Secondary Age Range on the Iowa Brace Test.

	BOYS		GIRLS	
Raw Score	11+ Sample N = 416 T.Scores	Full Statutory Age Sample N = 824 T. Scores	11+ Sample N = 359 T. Scores	Full Statutory Age Sample N = 1148 T. Scores
20	73	73	75	74
19	68	66	71	69
18	63	63	67	65
17	61	59	63	62
16	58	55	61	59
15	55	52	58	56
14	53	49.	54	53
13	51	47	53	51
12	48	45	50	49
11	46	42	49	47
10	44	39	47	44
9	42	37	44	42
8	40	35	43	40
7	37	33	39	37
6	35	32	37	35
5	34	30	34	32
4	32	28	32	30
3	29	26	29	28
2	26	23	27	25
1	24	22	24	22
0	-	-	-	-

BATTERY No. 2.

TABLE EIGHT

Boys - Item No. 1 Speed Test - N = 590

Time in Secs.	f
30.5 to 31.4	1
31.5 to 32.4	4
32.5 to 33.4	4
33.5 to 34.4	12
34.5 to 35.4	28
35.5 to 36.4	61
36.5 to 37.4	63
37.5 to 38.4	83
38.5 to 39.4	99
39.5 to 40.4	112
40.5 to 41.4	50
41.5 to 42.4	21
42.5 to 43.4	17
43.5 to 44.4	14
44.5 to 45.4	12
45.5 to 46.4	4
46.5 to 47.4	3
47.5 to 48.4	1
48.5 to 49.4	1

Mean 38.8 secs ($\pm$ 0.109)

to nearest tenth of a second

SD = 2.65 seconds

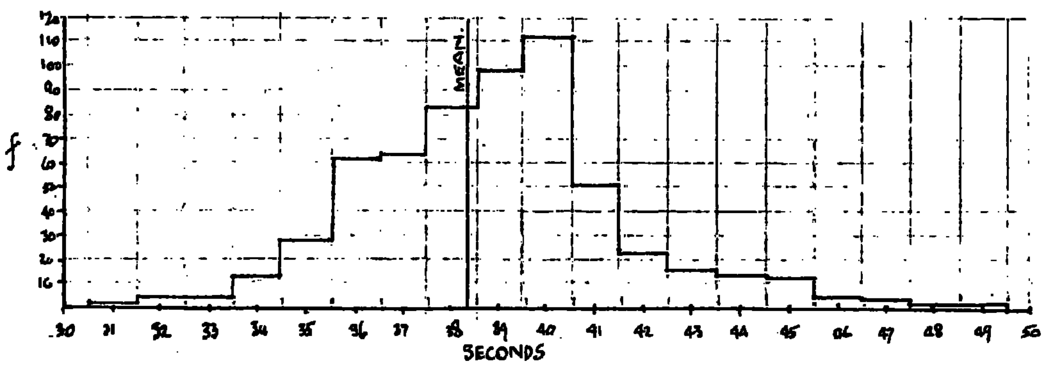


TABLE NINE.

BOYS - ITEM NO. 2 PULL UPS - N = 443

Number of Pull Ups		f.
29	30	4
27	28	3
25	26	3
23	24	5
21	22	8
19	20	11
17	18	21
15	16	35
13	14	42
11	12	71
9	10	74
7	8	56
5	6	54
3	4	38
1	2	14
	0	4

Mean = 10.5 repititions ($\pm$ 0.261)

S.D. = 5.5

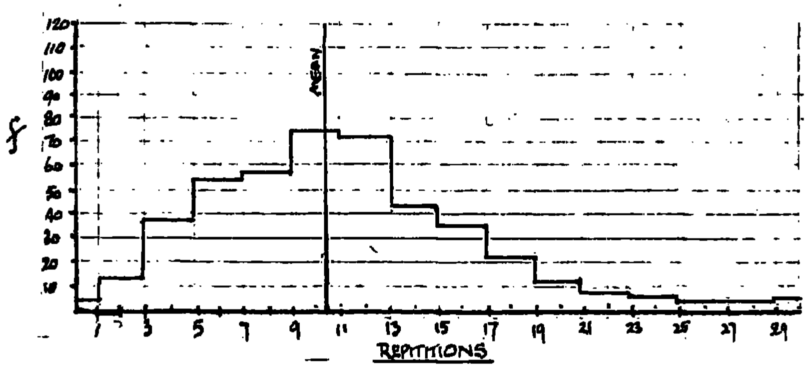


TABLE TEN

BOYS - ITEM NO. 3 STANDING BROAD JUMP - N = 495

Distance jumped			f
6'9¼"	to	6'11"	2
6'7¼"	to	6' 9"	3
6'5¼"	to	6' 7"	5
6'3¼"	to	6' 5"	4
6'1¼"	to	6' 3"	11
5'11¼"	to	6' 1"	12
5'9¼"	to	5'11"	25
5'7¼"	to	5' 9"	28
5'5¼"	to	5' 7"	52
5'3¼"	to	5' 5"	45
5'1¼"	to	5' 3"	61
4'11¼"	to	5' 1"	72
4'9¼"	to	4'11"	25
4'7¼"	to	4' 9"	31
4'5¼"	to	4' 7"	39
4'3¼"	to	4' 5"	24
4'1¼"	to	4' 3"	18
3'11¼"	to	4' 1"	18
3'9¼"	to	3'11"	7
3'7¼"	to	3' 9"	5
3'5¼"	to	3' 7"	7
3'3¼"	to	3' 5"	1

Mean = 5'1.1" (± 0.343")

S.D. = 7.64"

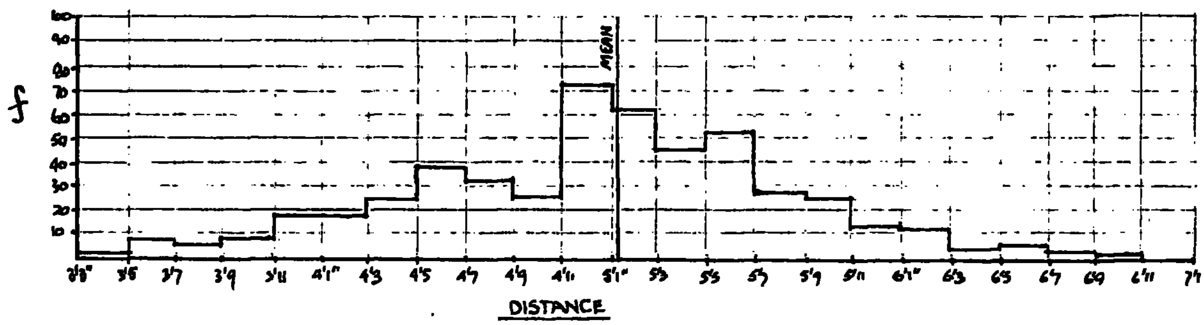


TABLE ELEVEN

BOYS - ITEM NO. 4 MEDICINE BALL THRUST

N = 635

Distance in Feet & Inches	f
11'3½" to 11'9"	1
10'9½" to 11'3"	2
10'3½" to 10'9"	5
9'9½" to 10'3"	8
9'3½" to 9'9"	15
8'9½" to 9'3"	32
8'3½" to 8'9"	29
7'9½" to 8'3"	40
7'3½" to 7'9"	35
6'9½" to 7'3"	66
6'3½" to 6'9"	60
5'9½" to 6'3"	100
5'3½" to 5'9"	66
4'9½" to 5'3"	81
4'3½" to 4'9"	35
3'9½" to 4'3"	31
3'3½" to 3'9"	12
2'9½" to 3'3"	13
2'3½" to 2'9"	3
1'9½" to 2'3"	1

Mean = 6' 4.25" (± 0.793")

S.D. = 19.98" (20" approx.)

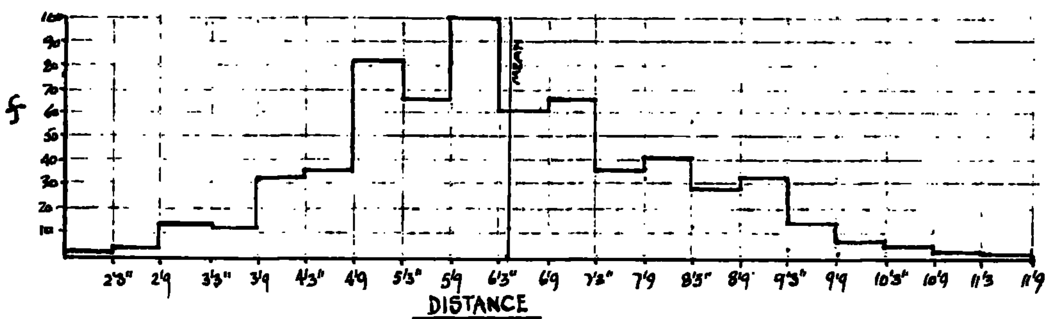


TABLE TWELVE

BOYS - ITEM NO. 5 JUMP REACH - N = 582

Height in Inches	f
$15\frac{3}{4}$ to $16\frac{1}{2}$	2
$14\frac{3}{4}$ to $15\frac{1}{2}$	18
$13\frac{3}{4}$ to $14\frac{1}{2}$	26
$12\frac{3}{4}$ to $13\frac{1}{2}$	57
$11\frac{3}{4}$ to $12\frac{1}{2}$	94
$10\frac{3}{4}$ to $11\frac{1}{2}$	108
$9\frac{3}{4}$ to $10\frac{1}{2}$	123
$8\frac{3}{4}$ to $9\frac{1}{2}$	87
$7\frac{3}{4}$ to $8\frac{1}{2}$	45
$6\frac{3}{4}$ to $7\frac{1}{2}$	14
$5\frac{3}{4}$ to $6\frac{1}{2}$	6
$4\frac{3}{4}$ to $5\frac{1}{2}$	1
$3\frac{3}{4}$ to $4\frac{1}{2}$	1

Mean = 10.8" ($\pm$ 0.081")
to nearest $\frac{1}{4}$" = $10\frac{3}{4}$"

S.D. = 1.943"

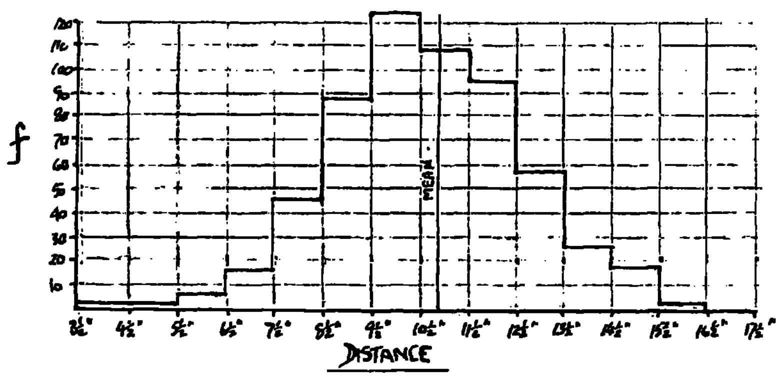


TABLE THIRTEEN

BOYS - ITEM NO. 6 PRESS UPS - N = 521

Number of Repititions	f
25	3
24	2
23	1
22	4
21	3
20	3
19	4
18	9
17	5
16	8
15	14
14	14
13	24
12	37
11	31
10	54
9	44
8	36
7	42
6	40
5	29
4	42
3	33
2	18
1	16
0	5

Mean = 8.5 to nearest half (8.509 ± 0.218)

S.D. = 4.81

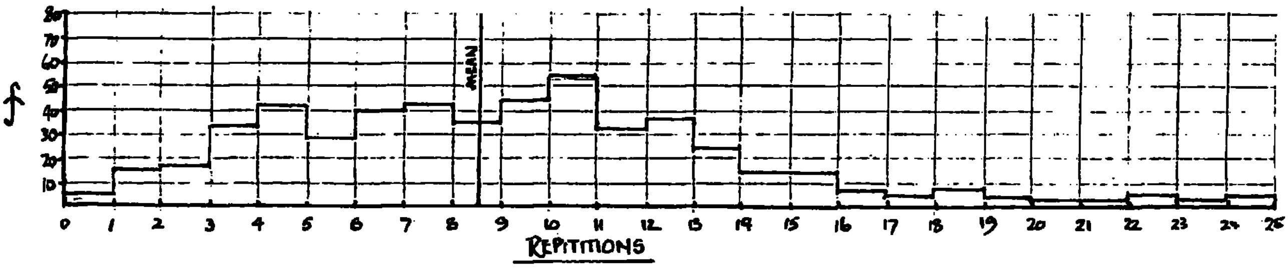


TABLE FOURTEEN

GIRLS - ITEM NO. 1 SPEED TEST - N = 432

Time in Seconds	f
32.5 to 33.4	1
33.5 to 34.4	2
34.5 to 35.4	8
35.5 to 36.4.	14
36.5 to 37.4	23
37.5 to 38.4	72
38.5 to 39.4	65
39.5 to 40.4	76
40.5 to 41.4	62
41.5 to 42.4	39
42.5 to 43.4	30
43.5 to 44.4	18
44.5 to 45.4	10
45.5 to 46.4	5
46.5 to 47.4	2
47.5 to 48.4	3
48.5 to 49.4	2

Mean = 40.054 secs. (± 0.121)
(taken to be 40 secs.)

S.D. = 2.51 secs.

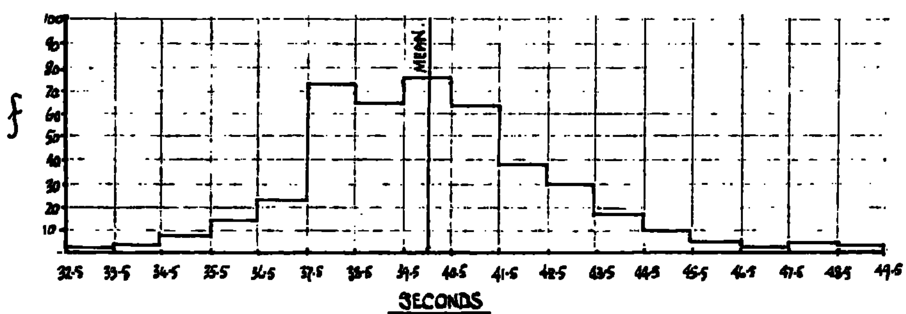


TABLE FIFTEEN

GIRLS - ITEM NO.2 PULL UPS - N = 450

Number of Repititions	f
29 and 30 (cut off point)	8
27 and 28	2
25 and 26	2
23 and 24	3
21 and 22	5
19 and 20	10
17 and 18	9
15 and 16	25
13 and 14	38
11 and 12	56
9 and 10	77
7 and 8	68
5 and 6	77
3 and 4	50
1 and 2	14
0	6

Mean = 9.500 ($\pm$ 0.274)

S.D. = 5.54

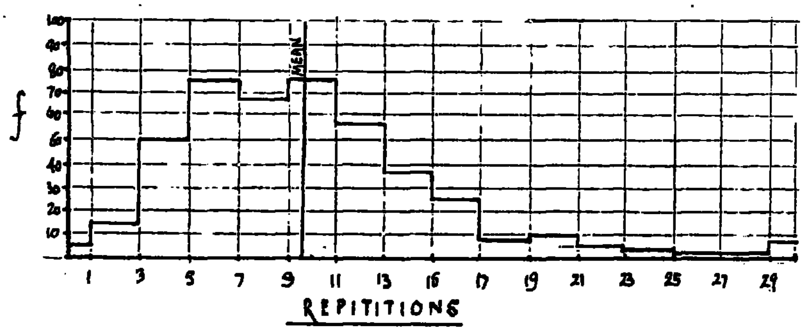


TABLE SIXTEEN

GIRLS - ITEM NO. 3 STANDING BROAD JUMP - N = 541

Distance in feet and inches	f
6'9¼" to 6'11"	2
6'7¼" to 6' 9"	3
6'5¼" to 6' 7"	3
6'3¼" to 6' 5"	2
6'1¼" to 6' 3"	10
5'11¼" to 6' 1"	21
5'9¼" to 5'11"	21
5'7¼" to 5' 9"	15
5'5¼" to 5' 7"	31
5'3¼" to 5' 5"	37
5'1¼" to 5' 3"	43
4'11¼" to 5' 1"	61
4'9¼" to 4'11"	49
4'7¼" to 4'9"	42
4'5¼" to 4' 7"	66
4'3¼" to 4' 5"	43
4'1¼" to 4' 3"	38
3'11¼" to 4' 1"	25
3'9¼" to 3'11"	10
3'7¼" to 3' 9"	11
3'5¼" to 3' 7"	4
3'3¼" to 3' 5"	2
3'1¼" to 3' 3"	1

Mean = 4' 11.385" (± 0.339)
(taken to be 4'11¼")

S.D. = 7.8"

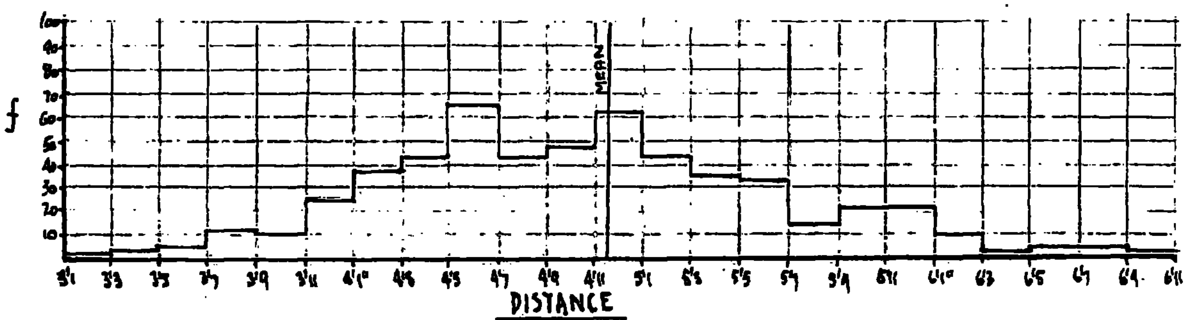


TABLE SEVENTEEN

GIRLS - ITEM NO. 4 MEDICINE BALL THRUST - N = 454

Distance in feet and inches	f
10' 3½" to 10' 9"	1
9' 9½" to 10' 3"	4
9' 3½" to 9' 9"	3
8' 9½" to 9' 3"	5
8' 3½" to 8' 9"	11
7' 9½" to 8' 3"	21
7' 3½" to 7' 9"	31
6' 9½" to 7' 3"	42
6' 3½" to 6' 9"	30
5' 9½" to 6' 3"	60
5' 3½" to 5' 9"	49
4' 9½" to 5' 3"	61
4' 3½" to 4' 9"	31
3' 9½" to 4' 3"	42
3' 3½" to 3' 9"	25
2' 9½" to 3' 3"	22
2' 3½" to 2' 9"	16
1' 9½" to 2' 3"	9
1' 3½" to 1' 9"	1

Mean - 5' 11.27" (± 0.975)
(taken to be 5' 11¼")

S.D. = 1' 8.76"

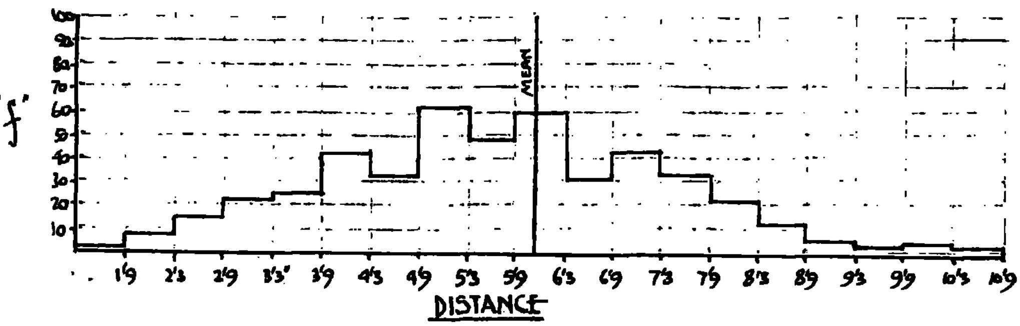


TABLE EIGHTEEN

GIRLS - ITEM NO.5 JUMP REACH - N = 455

Height in Inches	f
14 3/4" to 15 1/2"	2
13 3/4" to 14 1/2"	4
12 3/4" to 13 1/2"	16
11 3/4" to 12 1/2"	35
10 3/4" to 11 1/2"	40
9 3/4" to 10 1/2"	66
8 3/4" to 9 1/2"	83
7 3/4" to 8 1/2"	87
6 3/4" to 7 1/2"	59
5 3/4" to 6 1/2"	37
4 3/4" to 5 1/2"	17
3 3/4" to 4 1/2"	6
2 3/4" to 3 1/2"	2
1 3/4" to 2 1/2"	1

Mean = 8.936" ($\pm$ 0.102)

S.D. = 2.17"

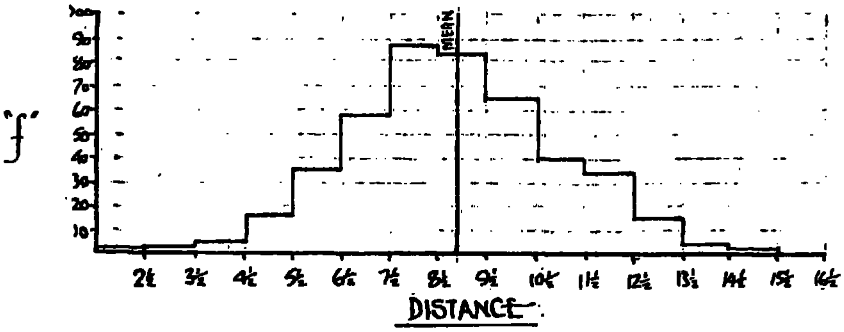


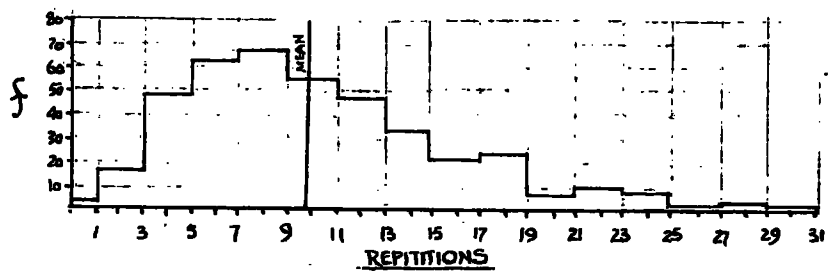
TABLE NINETEEN

GIRLS - ITEM NO.6 PRESS UPS (USING BENCH) - N = 414

Number of Repititions	f
30 (maximum)	1
29	0
28	1
27	2
26	0
25	1
24	6
23	3
22	7
21	3
20	5
19	3
18	11
17	12
16	12
15	9
14	21
13	13
12	16
11	31
10	30
9	26
8	24
7	44
6	37
5	25
4	25
3	24
2	8
1	10
0	4

Mean = 9.705 ($\pm$ 0.278)

S.D. = 5.68



The Auxiliary Experiment

TABLE TWENTY

The Correlation between Iowa Brace Test Results and Percentage Improvement in a Skill Test after Six Months' Practice.

A 1st Sample 1962/3 Mixed N = 36

No.	Pupil	Raw Score	T.Score x	2nd Test	1st Test	Percentage Improvement
1	K.B.(g)	16	59	37	19	45
2	D.T.(g)	18	65	32	15	42.5
3	K.S.(b)	18	63	38	22	40
4	J.L.(b)	11	39	30	20	25
5	B.P.(b)	12	42	29	17	30
6	J.H.(g)	11	47	29	15	35
7	S.M.(g)	9	42	28	19	22.5
8.	J.Ha.(b)	16	55	27	16	27.5
9	M.B.(g)	14	53	27	15	30
10	C.M.(b)	11	47	27	21	15
11	A.W.(b)	16	59	26	13	32.5
12	B.W.(g)	12	49	26	21	12.5
13	M.R.(g)	14	53	24	13	27.5
14	A.C.(g)	13	51	24	17	17.5
15	M.S.(g)	11	47	26	22	10
16	J.P.(b)	18	55	24	12	30
17	H.H.(g)	9	42	20	16	10
18	L.W.(g)	11	47	29	21	20
19	B.M.(g)	8	40	18	16	5
20	D.G.(g)	8	40	19	15	10
21	S.Re.(g)	11	47	28	12	40
22	M.J.(g)	13	51	25	21	10
23	J.F.(g)	15	56	26	18	20
24	J.U.(g)	13	51	33	18	37.5
25	S.M.(g)	14	53	28	11	42.5
26	A.C.(g)	12	49	24	14	25
27	E.H.(g)	11	47	22	16	15
28	S.B.(b)	16	55	36	20	40
29	K.W.(b)	16	55	35	18	42.5
30	J.R.(g)	7	37	24	18	15
31	S.Ra.(g)	6	35	22	15	17.5
32	G.D.(g)	5	32	19	17	5
33	F.S.(b)	12	45	31	20	27.5
34	L.T.(g)	7	37	21	18	7.5
35	K.U.(g)	11	47	22	16	15
36	P.L.(b)	14	49	32	21	27.5

X From Table Seven. British T Scores Calculated by the Author

Table Twenty continued:

R (by product-moment) of Iowa Brace T Score with percentage improvement = 0.652 (± 0.096)

The results of the three similar experiments were as follows:

B	2nd Sample 1963/4 Mixed	N = 32	R = 0.591 (± 0.116)
C	3rd Sample 1963/4 Boys	N = 37	R = 0.704 (± 0.083)
D	4 th Sample 1963/4 Boys	N = 26	R = 0.628 (± 0.119)

Taking Samples A and B together as the conditions of the experiment were as near identical as possible

A and B together	N = 68	R = 0.623 (± 0.074)

Taking Samples C and D together for the same reason

C and D together	N = 63	R = 0.674 (± 0.069)

The only comments one can make on these results are:-

1. They bear out what has been discovered about the validity of the tests by the various methods used by American researchers (described in Chapter lV).
2. A fairly valid measurement of motor educability such as this one is, at the present stage of research, a useful measurement. There seems to be an urgent need for a test which will measure motor educability with a higher degree of accuracy.

IOWA BRACE TEST

The maximum score for the ten items being twenty points for b oth boys' and girls' tests, it is obvious from the mean scores, boys 13.676 (±0.126) and girls 12.326 (±0.116), that the samples found the test an easy one. This is confirmed by the facility indices for individual items and for the full test. Considering items one and six to be buffer items, as McCloy intended, the facility indices for the full tests were still boys 63.28% and girls 57.58%. Facility limits have been variously established by physical education researchers at 10 and 90% (i.e. those items answered by less than 10% or more than 90% are dropped), 7 and 93%, and 5 and 95%.[X] If one accepts these limits then each one of the items is acceptable on the score of facility although it is realized that in mental testing an index of between 25 and 85% is generally considered necessary for an item to be included in the final test battery. In the same way lower indices of discrimination (in the order of 0.25) seem to be considered quite acceptable in health and physical education testing.

Many researchers have shown that motor educability is not significantly correlated with intelligence and this conclusion is accepted by the author. However, for some reason the scores in Table Three (Page 125) tend to demonstrate that there is a positive correlation as school C, which gained 74.66% of the total marks, and school J, which gained 70.98%, are both secondary

X See "Application of Measurement to Health & Physical Education", by Clarke H. Pages 50,51.

grammar schools. School K (70.33%) is a comprehensive school and school M (68.39%) is a technical school. The four second--ary modern school A,E,F and N averaged a significantly lower percentage score than these and school L, which is a school for educationally sub-normal pupils, had far and away the lowest percentage score of 27.19% This trend was not so obvious in Table Four (page 126) where the two grammar schools for girls, represented by letters B and C, did not score significantly higher than the secondary modern schools.

"T" Scores as devised by McCall (96) are normalized standard scores converted into a distribution with a mean of fifty and a standard deviation of ten. It will be seen from Table Seven (Boys) that throughout the range the British sample scored slightly less than the American boys. Approx--imately 5.5% of the Americans obtained the maximum score and only 1.1% of the British sample achieved this. 53.98% of the Americans had scores below 15 and 57.93% of the British. Only 0.82% of the Americans and 2.28% of the British scored less than 5 out of 20. From the table of girls' scores it is obvious that the American girls score much higher than those of the British sample. Table Seven "A" shows that within the British sample the full statutory age group score better than the 11+ sample which tends to support McCloy's contention that this should be so.

BATTERY NO. 2.

The scores obtained on the speed test, the standing broad jump and jump reach, when plotted by natural histogram, gave an appearance of approaching normality. The medicine ball thrust test, although somewhat elongated at the upper end was also reasonably normal in shape. On the other hand the histograms of the two strength tests were negatively skewed as had been expected, previous researchers having shown this type of result to be common in strength tests. The difficulty here is that there is such a wide range of ability to be measured that making the test easy enough for the weaker pupils to gain a score considerably increases the number of repititions which the stronger are capable of doing, thus greatly increasing the time necessary for the test and the possibility of error. Other considerations also had to be borne in mind in deciding the scoring system of the two tests and these are discussed later in the present Chapter.

The method used in the construction of the scoring tables was to assign a score of 10 to performances, which were at least three standard deviations above the mean and to assign a score of 0 to performances which were three standard deviations or more below the mean. The performances between the mean and 10 were divided into five equal intervals and the performances between 0 and the mean were also divided into five equal intervals, giving a range of scores from 0 to 10 contained in $\pm$ three standard deviations from the mean. This method worked well for all but the strength tests and was later confirmed as sound when the validation sample (an entirely fresh one) produced scores which were normal in pattern. The scoring of the strength tests required further thought. The author had noticed during the performance of these tests that when called on to repeat them a small proportion of the weaker members were loth to do so, something which never occurred in any of the other tests. A further small group quite obviously tried extremely hard and one or two of these finished in quite a distressed condition from which, however, they quickly recovered. Clinical psycho--logists are evidently familiar with this phenomenon in studying personality traits (97) where the factor of persistence inter--venes, often reducing the reliability of a test by altering the retest scores. After some experience with the strength tests the author decided that in view of the above and also because it was realized that a test to exhaustion point was quite unnecessary, being out of keeping with the spirit and purpose of the test battery, that an arbitrary cut off point would have to be introduced. A maximum of 30 repititions had been placed on the pull-up tests quite early in the test series, and of course the author and his colleagues were ever alert for signs of undue strain before the limit. At the same time the boys' press-ups had been limited to 25 repititions and the girls' test made easier by the introduction of benches. Unfortunately some pupils knew what the maximum score in a test was and strove mightily and overanxiously to attain it. The author realized that although he wanted maximum effort it would be preferable if the pupils being tested did not know what this maximum was, but in cases where strain was apparent, a quiet "thanks, that's enough, well done!" from the administrator would solve the problem rather than having a rigid arbitrary known limit.

The full scoring tables for battery No. 2 are included on the next two pages. In using them it must be remembered that in scoring the tests there are limitations imposed by the apparatus used and, although the tests are objective in character, the accuracy of scoring can be affected by:-

(a) the differences of reaction times of the persons holding the stop watch in the speed test,

(b) the subjective interpretation of what constitutes half a point in any of the repitition tests,

(c) the subjective judgment of exactly where a pupil's foot landed in the broad jump.

The difference between the press-up test in the boys' and the girls' battery must be remembered when making comparisons of boys' and girls' scores.

TABLE TWENTY ONE - BOYS SCORING TABLE - TEST BATTERY No.2

Score	Speed Test	Pull Ups	St.Br. Jump	M.B. Thrust	Jump Reach	Press Ups
	Secs.	Repitions	Ft.& Ins.	Ft.& Ins.	Inches	Repititions
10	31.5 & below	25 & above	6'9½" & above	10'10½" & above	16½" & above	20 & above
9	31.6 to 33.1	22.5 to 24.5	6'5" to 6'9"	9'10½" to 10'10"	15¼" to 16¼"	18 to 19.5
8	33.2 to 34.7	20 to 22	6'0½" to 6'4½"	8'10½" to 9'10"	14" to 15"	16 to 17.5
7	34.8 to 36.3	17.5 to 19.5	5'8" to 6'0"	7'10½" to 8'10"	12¾"to 13¾"	14 to 15.5
6	36.4 to 37.9	15 to 17	5'3½" to 5'7½"	6'10½" to 7'10"	11½"to 12½"	12 to 13.5
5	38 to 39.5	12.5 to 14.5	4'11" to 5'3"	5'10½" to 6'10"	10¼"to 11¼"	10 to 11.5
4	39.6 to 41.1	10 to 12	4'6½" to 4'10½"	4'10½" to 5'10"	9" to 10"	8 to 9.5
3	41.2 to 42.7	7.5 to 9.5	4'2" to 4'6"	3'10½" to 4'10"	7¾" to 8¾"	6 to 7.5
2	42.8 to 44.3	5 to 7	3'9½" to 4'1½"	2'10½" to 3'10"	6 ½" to 7½"	4 to 5.5
1	44.4 to 45.9	2.5 to 4.5	3'5" to 3'9"	1'10½" to 2'10"	5¼" to 6¼"	2 to 3.5
0	46 and above	0 to 2	3'4½" & below	1'10½" & below	5" and below	0 to 1.5

TABLE TWENTY TWO - GIRLS SCORING TABLE - TEST BATTERY No.2

Score	Speed Test	Pull Ups	St.Br. Jump	M.B. Thrust	Jump Reach	Press Ups
	Secs.	Repititions	Ft.& Ins.	Ft.& Ins.	Ins.	Repititions
10	33.2 and under	24 and above	6'7½" & above	10'5½" & above	14¾ & above	24 and above
9	33.3 to 34.7	21.5 to 23.5	6'3" to 6'7"	9'5½" to 10.5"	13½ to 14½	21.5 to 23.5
8	34.8 to 36.2	19 to 21	5'10½" to 6'2½"	8'5½" to 9'5"	12¼ to 13¼	19 to 21
7	36.3 to 37.7	16.5 to 18.5	5'6" to 5'10"	7'5½" to 8'5"	11 to 12	16.5 to 18.5
6	37.8 to 39.2	14 to 16	5'1½" to 5'5½"	6'5½" to 7'5"	9¾ to 10¾	14 to 16
5	39.3 to 40.7	11.5 to 13.5	4'9" to 5'1"	5'5½" to 6'5"	8½ to 9½	11.5 to 13.5
4	40.8 to 42.2	9 to 11	4'4½" to 4'8½"	4'5½" to 5'5"	7¼ to 8¼	9 to 11
3	42.3 to 43.7	6,5 to 8.5	4'0" to 4'4"	3'5½" to 4'5"	6 to 7	6.5 to 8.5
2	43.8 to 45.2	4 to 6	3'7½" to 3'11½"	2'5½" to 3'5"	4¾ to 5¾	4 to 6
1	45.3 to 46.7	1.5 to 3.5	3'3" to 3'7"	1'5½" to 2'5"	3½ to 4½	1.5 to 3.5
0	46.8 and above	1 and below	3'2½" and below	1'5" and below	3¼ and below	1 and below

C H A P T E R VIII

THE EXPERIMENT - PHASE TWO

Reliability of the Test Items.

The reasons why the test-retest method of finding the reliability of the Iowa Brace items is unlikely to be successful have been fully discussed elsewhere, therefore the split-half method was used. McCloy (98) calculated the reliability of the full test by matching the scores on items 1, 2, 3, 4 and 5 with those of items 6, 7, 8, 9, and 10. The author decided to use the more orthodox method of correlating the even-numbered tests with the odd-numbered tests, correcting the results by use of the Spearman Brown Prophecy Formula.

The six items of test battery Number 2 were tested for reliability by the test-retest method. Each pupil in the try out having recorded four scores on each test after a considerable amount of preliminary practice, the better of the first two scores was correlated with the better of the second two scores. The product-moment method of correlation was used.

TABLE TWENTY THREE

Statement of Reliability

Iowa Brace Items	by split half method taking alternate items. Corrected by Spearman Brown Prophecy Formula			
	r	N	M	SD
Boys	0.862	824	13.676	3.62
Girls	0.793	1148	12.326	3.93

Test Battery No. 2 Items by test-retest method.

BOYS

Test Item	rtt	N	M	S.D.
1. Speed Test	0.908	590	38.8 secs.	2.65 secs.
2. Pull Ups	0.858	443	10.49	5.56
3. St.Br. Jump	0.898	495	5'0.8"	7.64"
4. M.B. Thrust	0.876	635	6'4.2"	19.98"
5. Jump Reach	0.898	582	10.83"	1.94"
6. Press Ups	0.712	521	8.48	4.81

GIRLS

Test Item	rtt	N	M	S.D.
1. Speed Test	0.880	432	40.01 secs	2.51 secs.
2. Pull Ups	0.804	450	9.56	5.82
3. St.Br. Jump	0.928	541	4' 11.38"	7.8 "
4. M.B. Thrust	0.747	454	5' 11.27"	20.76"
5. Jump Reach	0.887	455	8.94"	2.17"
6. Press Ups	0.734	414	9.71	5.68

Determining the Validity of the Full Test Battery

Having evolved a scoring system and shown the test items to be reliable and practicable, the next step was to determine whether the composite test battery did, in fact, measure accurately what it was supposed to measure. A fresh sample was chosen from the new intake (1963/64) of several of the schools which had taken part in phase one of the experiment. The advantage of this was felt to be that the administrators would have benefited from their previous experience, particularly in the knowledge of how to demonstrate the test items and how to organise the most advantageous rotation of test battery Number 2 in their own particular gymnasia. It is considered, in American physical education testing research, that a sample of between one hundred and three hundred persons X is necessary at this stage to form a validation sample. The number of one hundred is counted as being acceptable where all the subjects are "well disciplined, if they endeavour to put forward their best efforts, ------- and if there are no discordant elements". The author decided to try to organise a sample which well exceeded three hundred in both boys' and girls' sections, in order to ensure that the maximum number, or as near this as possible, should be finally attained. In the event the boys' validation sample consisted of just over four hundred and the girls' sample numbered two hundred and thirty nine. Care was taken to form the sample from as near the whole range of mental ability and in the correct proportion as practicably possible. The following table shows the numbers of pupils and their types of school.

TABLE TWENTY FOUR THE VALIDATION SAMPLE

Types of School attended by Members of the Sample

BOYS

Type of School	No.	% Age (to nearest whole number)
Secondary Grammar	89	22
Comprehensive (Technical Stream)	33	8
Secondary Modern plus Secondary Modern Stream of Comprehensive	264	66
E.S.N.	16	4
Total	402	100

X Ref. (8) Page 34.

GIRLS

Type of School	No.	% Age (to nearest whole Number)
Secondary Grammar	34	14
Secondary Modern	190	80
Special Class in Secondary Modern	15	6
Total	239	100

It is regretted that owing to circumstances outside the author's control, the girls' sample was neither quite so large nor quite so well balanced as the author would have wished. On the other hand, allowing for the fluctuations in methods of entry to secondary schools in various parts of the country, and the necessity of working with groups rather than individuals, the author considered that the boys' group was very well balanced and the girls' group reasonably well balanced.

The Criterion.

The problem of what constitutes success in physical education is a thorny one. In academic subjects there is usually some external examination held several years after the selection which is used as an indication as to whether the selection has been successful or not. Even then some would argue that a boy who had contributed much to the life of a school, and been Head Boy or chairman of school societies could hardly be counted as an educational failure in the broadest sense of the word because he gained low marks in an external examination. In their search for criteria which would be suitable and generally acceptable for measuring success, physical education researchers have used a variety of methods which may or may not appear suitable to workers in other fields of testing and measuring human abilities. At one extreme is the "informed subjective judgment" used by McHone et al (68) and at the other "the sum of the T scores of forty-one motor tests, each of which was considered to represent some aspect of the seven specific elements into which general athletic ability had been analysed" used by Cozens (99). Very few researchers in physical education have attempted to validate a new test by correlating it to an older established test.[X] In the case of the present study the author could find no available test which would measure his chosen field of study with a sufficient degree of accuracy to be used as a criterion measure.

The author claims that the first step in ensuring the validity of his test battery was taken in the critical thinking about the problem which is reported in Chapter VI (Pages 69 to 74). Although this cannot be used in the accepted sense as a criterion measure, it has, by analysing the chosen area of motor ability in terms of its elements, formed the basis on which the test has been constructed. It is admitted that the analysis was based on what is being taught, without giving consideration to the author's opinions of what should be taught. After much deliberation, weighing the advantages of one method against another, it was decided to use a composite criterion of two

X Clarke (18) P.31 says "The practice of validating a new test with an established procedure has not been followed to any extent in physical education".

parts,[X] each to have equal value in arriving at the criterion score:-

(a) Subjective judgment by experts using a rating scale.

(b) Total score on a series of attainment tests.

The first part of the criterion, a measure of general gymnastic ability, was scored out of fifty by the teacher in charge of the class in collaboration with the author if present, or another colleague if the author was not present. The teachers were asked to use a five point scale and to assume a roughly normal range of ability in the class so that the scores of the majority would be between 15 to 35. A few outstandingly successful pupils to reach scores approaching 50 and at the other end a few, rated as unsuccessful, approaching zero.

The author's original idea for the second part of the criterion measure was to find five activities commonly taught by all schools taking part in the validation tests during the first half of the first year of the secondary course. The skills to be of a type which was basic to the area of ability being measured, but at the same time as far removed in content from the testing material as possible. What was not taken into sufficient consideration was the variety of topics which individual boys' and girls' schools teach and the differing methods and times of teaching them. It would have been an unwarrantable imposition on a band of willing collaborators to ask them to change their schemes of work to suit the author's

X Glover (5) in 1954 used a composite criterion of two parts in a similar manner.

convenience, therefore a compromise solution was found to be necessary. The compromise consisted of scoring five basic gymnastic activities from a group of seven, chosen by the author as being common to the first year schemes of the majority of the schools. The seven were:

(1) Forward Roll
(2) Backward Roll
(3) Headstand
(4) Handstand
(5) Cartwheel
(6) Astride vault over buck
(7) Through vault with box crosswise

The performance of each test was marked out of ten, by a maximum of four and a minimum of two competent judges, the average score being the one recorded. In the event there was a distinct thread of common activities chosen from the group, handstanding, forward or backward rolls, and cartwheels being included in all the test samples received. The maximum score on this section was also fifty, so that the total criterion score was expressed as a percentage.

It is claimed that the slight variations in part two of the criterion made, in practice, very little difference to the criterion scores and were justified in view of the everyday practical considerations attending an experiment of this size and scope, which demanded the close co-operation of so many people. The criterion measure was as thorough, as painstaking and as accurate as circumstances permitted.

The means and standard deviations of the total scores gained in the criterion measure worked out as follows:-

	No.	Mean Score %	S.D.
Boys	402	54.57	16.45
Girls	239	52.91	13.98

One point brought out distinctly, both by the author's observations and later confirmed by the statistics recorded above, was that women teachers seemed loth to use both ends of the measuring scale, tending to underscore what, to the author, were first class performances and yet at the other end boosting the scores of those who lamentably failed. The maximum criterion score awarded to a boy was 92% and the minimum score 6%. The maximum recorded girls' score was 88% and the minimum 19%.

The Establishment of the Final Battery

The score that represented the criterion and the total score from the test battery having been worked out, both the criterion measures and the test battery were administered to the two validation samples. The next steps were statistical in character, consisting of:-

1. Finding the coefficients of correlation between the criterion and each of the items of the whole test battery.
2. Finding the coefficients of correlation between the scores of each of the items in the test battery and the scores on each of the other items.

The Iowa Brace test was counted as a single item because it was felt that the facility and discrimination tests done in Phase One, and the item correlations of Table 23 produced sufficient knowledge of the individual items for the purposes of the test battery.

The Results of these calculations are set out in the following tables. The Iowa Brace Items are numbered one to ten and the items of test battery Number Two, eleven to sixteen. The Product-Moment method of correlation was used for test battery Number 2 and the Point Biserial method for the Iowa Brace Items.

TABLE TWENTY FIVE

The Correlations between Criterion Scores and each Item of the Test Battery - Boys.

Note: The items are placed in descending order of value of correlation coefficients.

Boys N = 402

Test Item No.	Name	R
16	Press Ups	0.569
13	Standing Broad Jump	0.554
11	Speed Test	0.540
12	Pull Ups	0.536
15	Jump Reach	0.528
8	Full Squat Arm Circle Test	0.475
9	Kneel Jump to Feet	0.395
14	Medicine Ball Thrust	0.373
2	Three Dip Test	0.346
4	Top Test	0.321
1	One Foot touch Head Test	0.293
10	Russian Dance Test	0.292
7	Grapevine Test	0.291
6	Side Leaning Rest Test	0.279
5	Double Heel Click Test	0.201
3	Half Turn Jump Test	0.079

TABLE TWENTY SIX

The Correlations between Criterion Scores and each Item of the Test Battery - Girls

Note: The items are placed in descending order of value of correlation coefficients.

GIRLS N = 239

Test Item No.	Name	R
13	Standing B road Jump	0.538
16	Bench Press Ups	0.496
4	Top Test	0.479
12	Pull Ups	0.466
9	Kneel Jump to Feet Test	0.394
11	Speed Test	0.374
5	Russian Dance	0.329
1	Side Leaning Rest Test	0.324
6	One Foot Touch Head Test	0.314
15	Jump Reach	0.258
14	Medicine Ball Thrust	0.216
8	Forward Hand Kick	0.200
3	Side Kick Test	0.197
10	Single Squat Balance	0.184
2	Full Squat Arm Circle Test	0.113
7	Half Turn Jump	0.094

TABLE TWENTY SEVEN

(a) Inter-correlations of Test Items - Boys

	11	12	13	14	15	16
1. Iowa Brace Items	0.421	0.524	0.536	0.274	0.489	0.441
11. Speed Test		0.409	0.541	0.028	0.522	0.430
12. Pull Ups			0.282	0.261	0.322	0.576
13. St. Br. Jump				0.332	0.523	0.396
14. Med. Ball Thrust					0.269	0.176
15. Jump Reach						0.265
16. Press - Ups						

(b) Inter-correlations of Test Items - Girls

	11	12	13	14	15	16
1. Iowa Brace Items	0.450	0.367	0.341	0.105	0.215	0.384
11. Speed Test		0.418	0.450	0.434	0.301	0.458
12. Pull Ups			0.321	0.306	0.260	0.460
13. St. Br. Jump				0.335	0.319	0.312
14. Med. Ball Thrust					0.276	0.248
15. Jump Reach						0.222
16. Bench Press U ps						

Lindquist's table[X] of the value of correlation coefficients required for significance at the five per cent and one per cent levels was used to test the significance of Tables Twenty five and Twenty six. This resulted in the immediate elimination of the half-turn jump test from both batteries as the correlations obtained were not significant at either level. The full squat arm circle test was eliminated from the girls' battery for the same reason. It will be seen from the phase one table of results of the facility and discrimination tests, (Page 128), that these items did not show up well from the start. The elimination of only one test from the boys' battery and two from the girls', on the stated grounds, gave the author the chance to balance the batteries by eliminating the three dip test from the boys' Iowa Brace items for quite different reasons, even though its statistical results were good.

It had become apparent that the similarity between this item and the press ups test of battery Number 2 was a disadvantage for two reasons:-

(a) In the necessary coaching of battery Number 2 items, given before the tests were administered, practice was obtained contrary to the rules of the Iowa Brace test.

(b) At the age of eleven plus, the item became very definitely a test of strength for some boys rather than of co-ordination,

X See "Statistical Analysis in Educational Research", by E.F. Lindquist. Reference No. 95. Page 212. Table 13.

which was its stated purpose.

All the remaining fourteen items were found to be significant at the one per cent level of confidence.[X1.] A check was now made, by leaving out the test item in each battery possessing the lowest coefficient of correlation with the criterion and computing the new coefficient of correlation between the criterion and the remaining tests. In the b oys' battery this immediately made a significant difference and so the test (test No. 5) was reinstated. In the girls' battery, item N o. 10 could well have been eliminated, but as the leaving out of the next lowest correlation (test No. 3) did significantly affect the result, it was left in to balance the halves of the Iowa Brace section in the final battery. This now consisted of two parts:-

(a) The eight remaining Iowa Brace items, five of which are common to both batteries.

(b) The full test battery Number 2.

In working out the norms of the full Iowa Brace Tests for the British Sample,[X2.] and later the facility indices,[X3.] it had become obvious that the scores gained by the sample were higher than was desirable, thus reducing the efficiency of the present test battery. The opportunity was now taken to adjust

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X1. Extract from Lindquist's table for convenience of the reader:

N	5%	1%
200	0.139	0.182
400	0.098	0.128

X2. See Page 129. Table Seven.

X3. See Page 145 line 8.

the scoring system to bring the mean scores down nearer the 50% level and at the same time improve the discrimination of this part of the battery. At the same time the author was keeping in mind the question of whether or not it would be necessary to complicate the scoring system and administration of the test battery by using a multiple regression equation to weight each sub test. The method first considered was to weight those test items which had been shown to be most efficient for the purposes of the test, in a quite arbitrary manner, by scoring them out of three instead of out of two, thus:-

(1) In the boys' test the following items were scored out of 3, with a score of $1\frac{1}{2}$ for success at the second attempt:-

(a) Item number four, which had been shown to have a facility index of 49.27, a discrimination index of 0.38 and a correlation of 0.321 with the criterion.

(b) Item number five, F = 40.17, D = 0.53, r = 0.201

(c) Item number nine, F = 57.58, D = 0.61, r = 0.395

(d) Item number ten, F = 35.56, D = 0.58, r = 0.292

(2) Similarly in the girls' test:-

(a) Item number four, F = 50.69, D = 0.55, r = 0.479

(b) Item number five, F = 52.57, D = 0.58, r = 0.329

(c) Item number eight, F = 52.22, D = 0.64, r = 0.200

(d) Item number nine, F = 46.52, D = 0.59, r = 0.394

This arbitrary method of weighting, somewhat fortuitously it is admitted, worked very well in practice. As the

X
—validation results show a high correlation with the criterion for the whole test with this simple system in operation, it was not considered necessary to introduce a more complicated weighting system. The order of performance of the Iowa Brace items in the final battery now became:-

<u>Boys</u>: 1, 7, 4, 5, 6, 8, 9, 10.

<u>Girls</u>: 1, 3, 4, 5, 6, 10, 8, 9.

Full details of the final battery are included in Chapter X.

<u>The Validation Statistics.</u>

The validation sample being of the nature described earlier in the present chapter, it was realized that it would not be good enough to calculate the full validity of the test in terms of the criterion by simply adding together the various obtained correlations and finding the average. The method followed was to use the product-moment method of calculating the validity of the test in each of the groups and then to pool the whole available information by means of Fisher's "z" transformation (101), thus at the same time it was possible to test for significance of the pooled correlation coefficient. Results of these calculations follow in Tables Twenty eight and Twenty nine.

X See pages 168 and 169.

TABLE TWENTY EIGHT

The Validation Sample - Boys

N - 402

Pooled Estimate of the Correlation between the Full Test Battery and the Criterion.

$$z = 1.15 \log \left(\frac{1+r}{1-r}\right)$$

Ref. No.	r	N	Z	(N-3)	Z(N-3)
B1	0.873	33	1.334	30	40.020
B2	0.824	33	1.167	30	35.010
B3	0.824	27	1.167	24	28.008
B4	0.807	28	1.118	25	27.950
B5	0.863	18	1.304	15	19.560
B6	0.887	28	1.406	25	35.150
B7	0.672	16	0.814	13	10.582
B8	0.727	30	0.927	27	25.029
B9	0.867	32	1.319	29	38.251
B10	0.864	28	1.307	25	32.675
B11	0.893	16	1.435	13	18.655
B12	0.662	36	0.795	33	26.235
B13	0.646	35	0.768	32	23.576
B14	0.849	42	1.250	39	48.750
		402		360	409.451

$$\text{Pooled } Z = \frac{409.451}{360} = 1.137$$

$$\text{now since } Z = 1.15 \log \left(\frac{1+r}{1-r}\right)$$

$$\text{we have } \log \left(\frac{1+r}{1-r}\right) = \frac{1.137}{1.15} = 0.9887$$

$$\therefore \frac{1+r}{1-r} = 9.743$$

$\therefore$ The pooled value of r = 0.814

But Z is distributed with a Standard error of $\frac{1}{\sqrt{360}}$ or $\frac{1}{18.974}$ or 0.053. The observed value of Z is over 20 times its standard error and highly significant.

TABLE TWENTY NINE

The Validation Sample - Girls

N - 239

Pooled Estimate of the Correlation between the Full Test Battery and the Criterion.

$$z - 1.15 \log \left(\frac{1+r}{1-r}\right)$$

Ref.No.	r	N	Z	(N-3)	Z(N-3)
G1	0.858	33	1.283	30	38.490
G2	0.643	32	0.762	29	22.098
G3	0.912	34	1.538	31	47.678
G4	0.564	31	0.638	28	17.864
G5	0.825	30	1.171	27	31.617
G6	0.870	31	1.330	28	37.240
G7	0.726	30	0.919	27	24.813
G8	0.716	18	0.898	15	13.470
		239		215	233.270

$$\text{Pooled } Z = \frac{233.27}{215} = 1.085$$

Calculating as in Table 28: $\log \left(\frac{1+r}{1-r}\right) = \frac{1.085}{1.15} = 0.9436$

$$\therefore 1 + r = 8.782 (1 - r)$$

$$\therefore r = 0.796$$

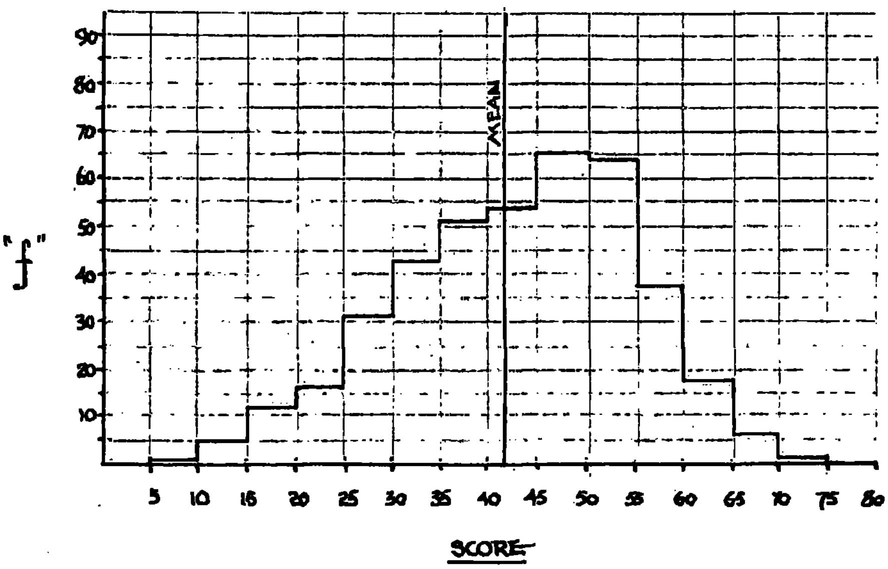
Z is distributed with a standard error of $\frac{1}{\sqrt{215}}$ or 0.068

∴ the observed value of Z is 16 times its standard error and therefore highly significant.

TABLE THIRTY

Natural H istogram showing Distribution of Scores Gained by Boys' Validation Sample on Final Test Battery. - N = 402

Maximum raw score possible is 80.



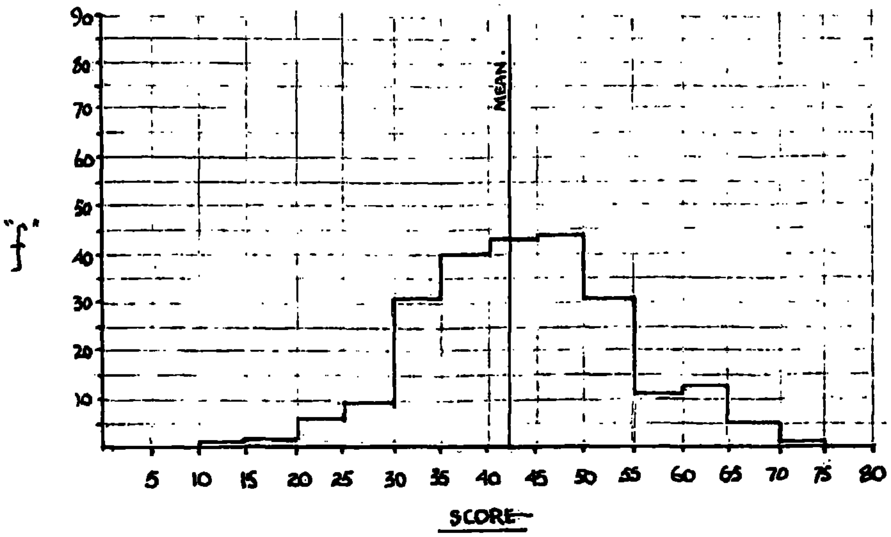
MEAN 42.297 (± 0.597)
S.D. 12.248 (± 0.424)

TABLE THIRTY ONE

Natural Histogram showing Distribution of Scores Gained by:
(a) Girls' Validation Sample - N = 239
(b) Validation Sample plus 69 scores received too late for inclusion in other Calculations - N = 308

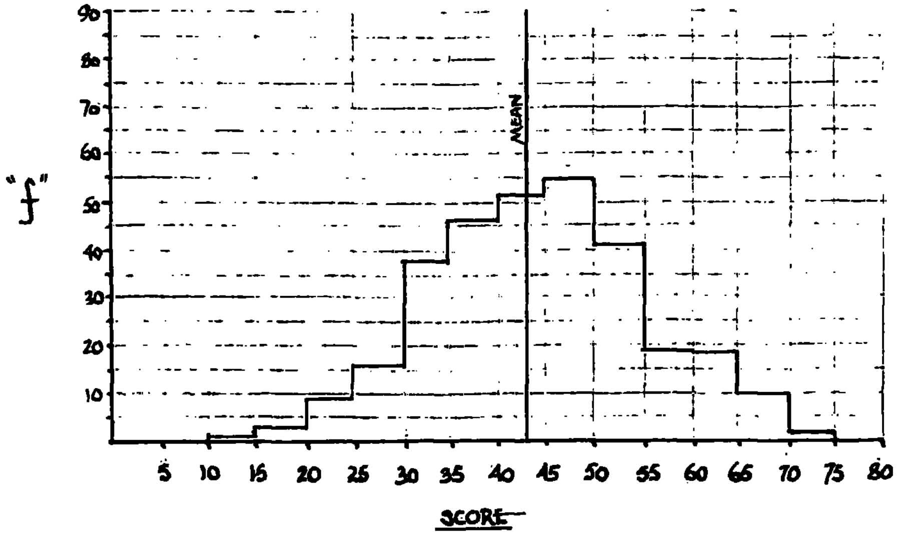
Maximum raw score possible is 80

(a)



MEAN 42·430 (±0·663)
S.D. 10·245 (±0·471)

(b)



MEAN 42·578 (±0·638)
S.D. 11·205 (±0·453)

General Observations on the Test Battery

The following points, learned during the author's experience in the administration of many tests, may be of interest:-

(a) There is no doubt that the vast majority of pupils tested tried their level best to "succeed". Much interest was created in the various schools concerning the purpose of the tests. The fact that many schools were taking part seemed to make the boys and girls even more determined. As pupils were allowed to carry round their score sheets they learned their own scores and these soon begain to have "prestige value". Teachers reported that, after the tests were completed, pupils asked for the circuit to be set up again so that they could either (1) try to reach the maximum score, or (2) improve the score they had got. Many children were observed trying to perform the Iowa Brace movements in the school yards. Summing up the author has little doubt that maximal effort was obtained.

(b) There is very little danger of injury to any pupil in performing the tests. The apparatus required is very elementary, and the only missile used, (the 5 lbs. medicine ball), travels such a short distance that simple safety precautions prevent accidents. In all his experience the author saw only one careless boy struck by the ball and then he was not injured. One or two of the floors used were in poor condition and it is just as well that the author insisted on plimsolls being worn for the tests, as jumping events on this type of floor would have been painful, if not dangerous, in bare feet.

One girl, a rather obese, heavy limbed type, in performing the speed test became dizzy, causing the test to be stopped. The author was afterwards on the look out for this happening again, but fortunately no one else was affected in this way.

(c) Although the instructions seemed clear and foolproof, it is admitted that some of the duller children found some of the items difficult to grasp. It is obviously better to aim at equality of comprehension rather than to stick rigidly to the single explanation where genuine cases of doubt occur.

(d) Glover (5) noticed that in the strength tests an interven--ing variable of courage or persistence was evident, especially in the retests. It is worthy of note that the press ups test scores lowest on reliability in both boys' and girls' tables.

(e) There was no evidence of undue fatigue being caused by the tests. The tests of battery Number two were arranged in a balanced sequence by the author. Even where this sequence was not strictly followed, (in one case the press up test followed the pull up test), only a few boys would admit that their arms ached and none showed distress.

(f) It is essential that care is taken with the observation of results. One of the weaknesses of the test battery is that its results depend in some cases on accurate observation. Close supervision over the scoring, by a minimum of two teachers, is desirable where the class is large. The author found it necessary with some classes, where another teacher was not available, to have the assistance of a senior boy or girl to supervise the scoring of the test items of battery Number two. If the test is to be successful it will have to be regarded seriously as a test and not a lesson, so that the scoring system can be properly supervised.

(g) The enthusiasm and manner of presentation of the administ--rator is an essential part of the success of the test battery. In a group mental test the usual major function of the administrator is to put the testees at their ease. Here, his, or her main function is to present the tests clearly, accurately and keenly, especially where coaching and demonstration are required.

(h) It became apparent during the tests that certain parts had possibilities of use in other spheres. Certainly a group from battery Number two may make a useful motor fitness test. The medicine ball thrust may give an indication of ability in shot putting. The jumping and speed tests have fairly obvious potential applied to athletics.

(i) As a matter of interest, when a small group of twenty educationally sub normal children was being tested, whose I.Q.'s were accurately known, the opportunity was taken to correlate the I.Q.'s with the test score. The resultant r of 0.38 was not significant at either the 5% or 1% level.

Factorial Analysis

None of the items of the final test battery are original movements, indeed one would find it difficult to devise a new form of movement for the human frame. In the 1930's researchers using Thurstone's methods made many factorial analyses, which have been fully reported in Chapters lV and V of the present study. The author accepts the findings of these analyses, in fact the original group of tests was chosen mainly by following their guidance, seeking a combination of tests which had been previously shown to measure the factors which the author claims make up the prescribed area of investigation.

Esther Cope (74) did the classic factorial analysis on the Iowa Brace items in 1938 when she identified the following six factors, (1) Dynamic energy, (2) flexibility, (3) balance, (4) semi-circular canal balance, (5) insight into the nature of the skill, (6) arm control. The items chosen by the author from the list of Iowa Brace items were those which showed the highest loadings in factors (2), (3), (4), (5) and (6). No one claims yet to have isolated a pure factor of motor educability, which is presumed by McCloy to consist of at least twenty five separate factors.

Press ups, pull ups and a very similar form of the medicine ball thrust test were included in Glover's 1954 factorial analysis (5). He used Thurstone's multiple factor method and found it necessary to carry out four rotations before arriving at the most satisfactory solution. Press ups (0.6567) and pull ups (0.6626) had the highest loadings in "dynamic arm and shoulder strength", whilst the medicine ball thrust (0.5744) was found to have a high loading of Glover's factor II, assumed to be "power" of arm and shoulder muscles.

The standing broad jump was shown by Larson's 1941 analysis (45) to contain a high loading of dynamic leg strength (0.6187). In addition both Larson (0.6069) and Glover (0.6658) found that variations of the jump reach test had high loadings of a factor which was obviously that which the author would call power.

The speed test in its present form has not received the same attention as the others, because this form is the author's own invention. Similar tests have been shown, as would be expected, to contain high loadings of a factor variously called speed or velocity of legs and feet, or speed of muscular contraction. In view of the clear evidence of these previous researches concerning thirteen of the fourteen items of the final battery, there seemed to be little point in carrying out a factor analysis.

Reliability of Test Battery Number 2 X

An estimate of the reliability of Test Battery No.2 was calculated by the test-retest method using part of the validation sample. Four attempts having been allowed at each item, the better of the first two scores was correlated with the better of the second two:

	rtt	N	M	S.D.
Boys:	0.927 (± 0.013)	121	42.11	12.07
Girls:	0.898 (± 0.018)	117	42.36	10.22

X For Reliability Coefficients of Iowa Brace Items See P.153.

CHAPTER IX

SUMMARY OF CONCLUSIONS

Summary of Conclusions.

1. The main aim of the study, to construct a test battery capable of measuring accurately the gross motor ability of boys and girls who have just entered the secondary stage of their education, has been achieved. The battery has been shown to be reliable and valid.

2. The battery is designed to provide a useful assessment of the ability of new entrants to all types of secondary school. The second part of the battery could also gauge progress and show deficiencies, if periodically applied.

3. The usefulness of the test will be much diminished if attempts are not made to remedy deficiencies brought out incidentally by the second part of the battery. In this sense the test could be useful in planning a suitable curriculum.

4. The author endorses Glover's belief that, with the present trend of schools becoming bigger and bigger, there is a need for homogen eous grouping to gain the maximum reward from physical education. The test battery is certainly accurate enough to indicate homogeneous groups.

5. The secondary aim, that of examining the possibilities of measuring motor educability within the chosen field of study, has been carried out. By an appraisal of past research a suitable test was selected, examined statistically, using a comprehensive British sample, and norms, in the form of "T" scores, established.

6. An auxiliary experiment was carried out, consisting of two parts, in which percentage improvements in the performance of gymnastic skills after six month's practice was correlated against Iowa Brace Scores. Correlations of 0.628 (± 0.074) and 0.674 (± 0.069) were obtained, demonstrating that the test is a fairly valid measure of motor educability. There is an urgent need for a test which will measure motor educability with a higher degree of accuracy.

7. The distributions in the arm strength tests present a positively skewed picture, suggesting that the tests are too hard. The author was unable to find any simple dynamic arm strength tests which did not exhibit this characteristic.

8. The present study only scratches at the surface of this vast field. There is a need for more research into such topics as:-

(a) The effects of personality traits on the rate of gross motor learning and the relationship of these traits to motor ability.

(b) The reasons for the apparent arm strength deficiency in British schoolchildren of this age.

(c) A comparison of the effects of mental and physical practice in the learning of gross motor skills.

(d) The adequacy of physical education in meeting present day needs.

(e) The effects of homogeneous grouping on the progress made by children in physical education.

CHAPTER X

The Final Battery, Instructions for Administration and a Conversion Table for changing Raw Scores to Normalized Standard Scores.

General Notes

1. It will be appreciated that to make the tests effective, as high a standard of measurement as possible is essential.
2. It is considered necessary for the test administrator to "have a go" at the Iowa Brace Items privately before introducing them to the children, as some of them may be found difficult to demonstrate. An alternative to this is to teach a demonstrator.
3. Scoring sheets, made up as in diagram, and pencils for recording the scores are needed for all the tests.

BATTERY No 1			
TEST NUMBER	1ST TRIAL	2ND TRIAL	SCORE
1			
2			
3			
4			
5			
6			
7			
8			
TOTAL SCORE			____

REFERENCE NUMBER:

BATTERY No 2				
TEST NUMBER	NAME	1ST TRIAL	2ND TRIAL	SCORE
1				
2				
3				
4				
5				
6				
TOTAL SCORE				____

NAME :	
FORM :	
SCHOOL :	
GRAND TOTAL SCORE :	____
NORMALIZED STANDARD SCORE :	____

4. The pupils record their attempts at the items as indicated on the following pages. The raw scores are calculated by the administrator according to the scoring instructions and converted into "T" scores by means of the conversion table on page 190.

5. The Iowa Brace items finally chosen are repeated here for the convenience of the reader, and to avoid confusion over the numbers. Explanations of the Iowa Brace items are to be found on pages 88 to 100, and of the items of Battery number 2 from page 107 to 114.. Photographs of the tests are included between the pages named.

6. If the full Iowa Brace test is used as a measure of motor educability, it is suggested that the British norms recorded on page 129 should be employed.

7. In a normal sized class (say of about 30) the Iowa Brace items take about thirty minutes to administer. The preliminary practice of the test battery Number 2 should be of thirty minutes duration, 5 minutes on each of the tests. The average time for the administration of the two trials of test battery Number 2 is about one hour. The total time required for the whole test is therefore two hours.

8. It is advisable to have a colleague or suitable senior pupils to supervise the recording and at the same time give advice where necessary.

Battery Number 1.[X]

(Eight of the Iowa Brace Items)

1. Range performers six to eight feet apart in double lines

X	X	O	O
X	X	O	O

2. Provide each performer with pencil and score blank. Have each performer fill in his name, class and school, and then exchange it with the pupil opposite him in the other line.

3. Explain the test and now to score it:

"We are going to take a test, made up of eight parts - some are easy, some hard, probably none of you will be able to do them all.

You will record the performances of each other.

The persons in one line will do four tests scored by partner. The performers and recorders will then be alter--nated and the second line will do all eight tests. The original performers will then complete the test.

Two trials will be allowed for each.

If partner does test correctly first time put X in column one, if he fails put O.

Only if he fails give second chance, if he then is success--ful place X in second column. If he fails again place O in second column.

DO NOT PERMIT PARTNER TO PRACTISE THE TEST.

In some tests you will have to count time, do it this way - one thousand, two thousand, three thousand.

When you have done a test correctly or had two tries, sit on the floor so that I will know you are ready for next.

When you are scoring your partner do not practise, watch the person you are scoring and pay no attention to anyone else."

X Following the lines suggested by McCloy. Ref.8, page 92.

4. Then

Demonstrate stunt (1) using standard instructions, also reading the instructions.

Don't forget to demonstrate what will cause failure and say score this 0 followed by correct demonstration which will be scored X.

N otes on the Iowa-Brace Test Items

1. Some of the tests in boys' section differ from those in girls' section. The tests must be done in the order shown.

2. The effect of practice makes a big difference to test results, so it is essential that the test be administ--ered exactly according to instructions.

Test Items - Boys

1. One-foot-touch-head test. Stand on left foot. Bend trunk forward and place both hands on the floor. Raise right leg, and extend it backward. Touch head to the floor, and return to the standing position without losing the balance. Failure: (a) not to touch the head to the floor; (b) to lose the balance.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

2. Grapevine test. S tand with heels together. Bend trunk forward, extend both arms down between legs and behind ankles, and hold fingers of hands together in front of ankles. Hold this position for five seconds. Failure: (a) to lose the balance; (b) not to hold fingers of both hands together; (c) not to hold the position for five seconds.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

3. Top Test. Sit, with lower legs flexed, on the floor. Put arms between legs, and under and behind knees, and grasp ankles. Roll rapidly around to the right, with the weight first over right knee, then over right shoulder, then on back, then on left shoulder, and then on left knee. Sit up, facing in the opposite direction from which the test was started. Repeat the movements from this position, and finish facing in the same direction from which the test was started. Failure: (a) to release the hold of ankles; (b) not to complete the circle.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

4. Double-heel-click test. Jump upward, clap feet together twice, and land with feet apart (any distance). Failure: (a) not to clap feet together twice; (b) to land with feet touching each other.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

5. Side-leaning-rest test. Sit on the floor, with lower legs extended, and feet together. Put right hand on the floor behind body. Turn to the right, and take a side leaning-rest position, resting the body on right hand and right foot. Raise left arm and left leg, and hold this position for five counts. Failure: (a) not to take the proper position; (b) not to hold the position for five counts.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

6. Full-squat-arm-circles test. Take a full-squat position, with arms sideward to the level of shoulders. Wave arms so that each hand makes a circle of about one foot in diameter, and at the same time jiggle body up and down. Continue the performance for ten counts. Failure: (a) to move feet; (b) to lose the balance; (c) to touch the floor with any other part of body than feet; (d) not to move hands in a circle; (e) not to jiggle up and down.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

7. Kn eel-jump-to-feet test. Kneel on both knees. Rest backs of toes on the floor. Swing arms, and jump to the standing position. Do not rock backward on toes, or lose the balance. Failure: (a) to curl toes and to rock backward on them; (b) not to execute the jump, and not to stand still after the standing position has been reached.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

8. Russian Dance.test. Squat. Raise one leg forward. Perform a Russian dance step by extending legs alternately while in a squat position. Perform four such steps, that is, two with each leg. Heel of forward foot may touch the floor. Heel of rear foot should strike hip on that side. Failure: (a) to lose the balance; (b) not to do the stunt twice with each leg.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

Note: Please remember that most of the item numbers have been changed: 2 was originally 7; 3 was originally 4; 4 was originally 5; 5 was originally 6; 6 was originally 8; 7 was originally 9; 8 was originally 10).

The maximum possible raw score is 20.

Test Items - Girls

1. Side-leaning-rest test. - See Boys No.5.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

2. Side-kick test. Swing left leg sideways to the left, jumping upward with right leg. Strike feet together in the air, and land with feet apart. Feet should strike together in a line that would go to the left of left shoulder. Failure: (a) not to swing leg enough to the side; (b) not to strike feet together in the air, to the left of the line of left shoulder; (c) not to land with feet apart.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

3. Top test. - See Boys No.3.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

4. Russian Dance test. - See Boys No. 8.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

5. One-foot-touch-head test. - See Boys No.1.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

6. Single-squat-balance test. Squat on either foot. With hands on hips, raise one leg forward. Hold this position for five counts. Failure: (a) to remove hands from hips; (b) to touch the floor with raised leg; (c) not to hold the balance for five seconds.

Score 2 for success in first trial, 1 for success in second trial having failed first, 0 for failure in both.

7. Forward-hand-kick test. Jump upward, swinging legs forward.

Bend trunk forward, and touch toes with both hands before landing. Keep lower legs in as straight a line as possible with upper legs. Failure: (a) not to touch toes with both hands before landing; (b) to bend lower legs more than forty-five degrees.

Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

8. Kneel-jump-to-feet test. - See Boys No. 7.

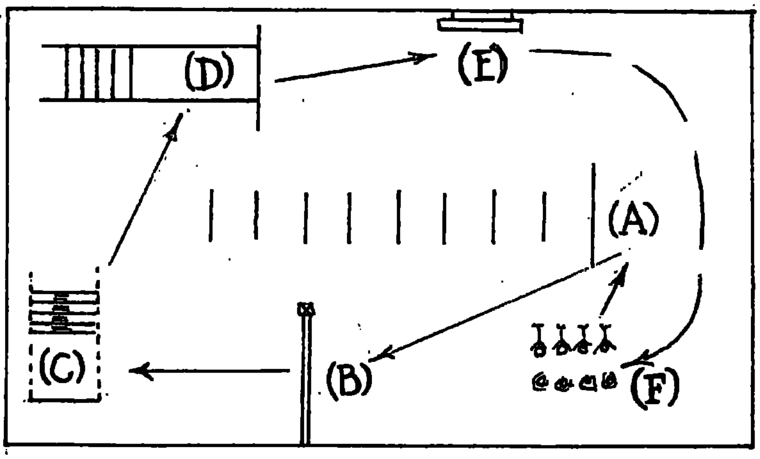
Score 3 for success in first trial, $1\frac{1}{2}$ for success in second trial having failed first, 0 for failure in both.

Note: Please remember that most of the item numbers have been changed: 1 was originally 2; 2 was originally 3; 3 was originally 4; 4 was originally 5; 5 was originally 6; 6 was originally 10; 7 was originally 8; 8 was originally 9.

The maximum possible score is 20.

Battery Number 2.

1. The six tests in the battery require that, where practicable, apparatus be laid out in the following manner, so that the time taken to administer the test is kept to a minimum. It should not affect the results of the test unduly if the layout is not practicable, but it is suggested that the pull ups and press ups test should not follow each other consecutively.



(A.) Item No. 1. Speed Test. - (See Page 107)

Apparatus required: Eight bean bags, stop watch and marked out course. If two sets of apparatus are available it is easy to test two performers at a time.

(B.) Item No.2. Pull Up Test. - (See Page 108)

Apparatus required: Beam set 24 inches from the floor.

(C.) Item No. 3. Standing Broad Jump. - (See Page 109)

Apparatus required: Start line on floor, long lines marking off jumps in 6" intervals from 3 ft. to 7 ft. from start line, shorter lines dividing intervals into inches, a measuring instrument and T square.

(D.) Item N o.4. Medicine Ball Thrust - (See Page 110)

Apparatus required: Supply of 5 lb. medicine balls, fibre or rubber mat, measuring apparatus similar to that used in test No. 3 from 1' 6" to 12' from the start line.

(E.) <u>Item No. 5. Jump Reach</u>. - (See Page 112)

Apparatus required: Either measuring board similar to the one designed by the author or another type as suggested on Page 112.

(F.) <u>Item No. 6. Press Ups</u>. - (See Pages 113, 114)

Apparatus required: boys - nil, girls - gymnastic benches.

2. The performers are given thirty minutes practice on the six items to familiarize them with the tests and the way the apparatus is set out. The best method of practice is the one commonly used in group work where the class is split into six groups, the groups moving to each piece of apparatus in turn. Coaching is allowed and is necessary so that the test may run smoothly.

3. The performers are so arranged in groups that, as far as possible, the pairs used for test battery Number 1 may be utilized.

4. In the test proper the same groups are used and two trials are allowed at each test, the better of the two trials is noted. The appropriate score is then read off from the scoring tables (See pages 150 and 151) and recorded.

5. The score cards are checked by the administrator to see that all the tests are completed. The raw scores are then calculated and the standard scores determined.

Normalized Standard Scores

Normalized standard scores are generally called T scores. T scaling was devised by McCall (96) in 1939, and consists of normalized standard scores converted into a distribution with a mean of 50 and standard deviation of 10. Thus zero is 5 Standard Deviations below the mean and 100 is 5 Standard Deviations above the mean. From this it will be seen that the ends of the scale will rarely be used. In actual practice T scores usually range from about 15 to 85.

Test Score	Boys T Score	Girls T Score
80	-	-
79	-	-
78	-	-
77	-	-
76	-	-
75	-	-
74	81	80
73	80	77
72	78	76
71	76.5	75
70	75	75
69	74	74
68	73	72.5
67	72	71
66	71.5	69
65	71	68.5
64	70	67
63	68.5	66
62	68	65
61	66.5	64
60	66	63.5
59	65	63
58	64	62.5
57	63	62
56	62	61
55	61	60.5
54	60	60
53	58.5	59
52	57.5	57.5
51	56.5	57
50	55.5	56
49	54.5	55
48	53.5	54
47	53	53
46	52	52
45	51	51
44	50.5	50.5
43	50	49
42	49	48.5
41	48	48
40	47.5	47
39	47	46
38	46	45
37	45.5	44
36	45	43.5
35	44	42.5
34	43.5	41.5
33	43	40.5
32	42	40
31	41.5	39
30	40.5	37.5
29	40	36.5
28	39	35.5
27	38	34.5
26	37.5	34
25	37	33
24	36	32
23	35	31
22	34.5	30.5
21	34	30.5
20	33	28
19	32	26.5
18	31	25
17	30	24
16	29	22.5
15	28	22.5
14	27	22.5
13	25	20.5
12	24	20
11	23	18
10	22	-
9	20	-
8	-	-
7	-	-
6	-	-
5	-	-

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(b) North Chadderton County Secondary School, Chadderton, Lancs. (Boys and Girls).
(c) Clara Lady Dorman County Secondary School, Redcar, Yorks. (Boys and Girls).
(d) St. Annes R.C. County Secondary School, South Bank, Yorks. (Girls)
(e) Cleveland Grammar School, Redcar, Yorks. (Girls)
(f) Kirkleatham Hall Special School, Kirkleatham, Yorks. (Boys)

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