ANTHROPOMETRIC MEASUREMENTS OF SKELETAL SEGMENTS AND THEIR RELATIONSHIP TO SELECTED PHYSICAL PERFORMANCE ITEMS FOR TEN-AND ELEVEN-YEAR OLD GIRLS

THESIS

Presented to the Graduate Council of

Southwest Texas State College

in Partial Fulfillment of

the Requirements

For the Degree of

Master of Arts

By

Judith K. Davenport, B.S.
(San Marcos, Texas)

San Marcos, Texas

June, 1966

ACKNOWLEDGMENTS

The cooperation of the San Marcos Independent School District and personnel at Bowie and Travis Elementary Schools made this study possible. A special note of thanks is extended to them and the students at these schools who participated by serving as subjects for the collection of data.

Grateful acknowledgment is made to the author's husband and the many friends who assisted the author in the various phases of this study.

Sincere gratitude and appreciation are expressed to Dr. Henrietta H. Avent whose advice, helpful criticisms, and encouragement helped guide the author through this study to its final form.

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CHAPTER I

INTRODUCTION

The idea of individual differences embodies many concepts--mental, social, emotional, and physical. Of these, physical differences are the only ones that are apparent to the human eye; the others have to be observed over a period of time or measured to obtain significant differences; however, in order to obtain the <u>same</u> significance, physical differences must be measured also.

Since physical education is basically education through the medium of physical activity, teachers in this area need to be aware of physical differences that affect student performance. Individual physical differences should be taken into consideration in the guidance of a student, in the selection of an activity, during instruction, and in evaluation of an individual's performance if these differences would affect their physical performance.

Statement of Problem

The investigation was conducted to determine whether or not a relationship exists between various anthropometric measurements of skeletal segments and selected physical performance items.

Delimitations

This study was delimited to 102 ten- and eleven-year old girls, showing no apparent physical defects, enrolled in Bowie and Travis Elementary Schools in San Marcos, Texas.

Definition of Terms

1. Acromion. "The acromion is the flat, somewhat triangular bony process formed by the lateral extension of the scapular spine, and situated just above the glenoid cavity."[1]

2. Anthropometric measurements and physical-performance chart. This is a chart devised by the author for the dual purpose of recording anthropometric measurements and physical-performance scores. It may be referred to simply as the measurement chart or the performance chart.

3. Anthropometry. Anthropometry is the art or system of measuring the human body and its parts;[2] thus reference may be made to anthropometric measurement.

4. Dactylion. Dactylion, as used in this study, refers to the extreme distal end of the middle finger, excluding the fingernail.

5. Glenoid cavity. The glenoid cavity is defined as the socket of the shoulder joint.

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[1]Norman L. Hoerr, M.D. and Arthur Osol, Ph.D., Blakiston's Illustrated Pocket Medical Dictionary, p. 11.

[2]Ales Hrdlicka, Anthropometry, p. 7.

6. Greater Trochanter. "The greater trochanter is one of two processes on the upper extremity of the femur below the neck and situated on the outer side of the bone."[3]

7. Measurement. Measurement refers to quantitative and qualitative data, collected by means of anthropometry or through physical performance, that can be expressed in numerical form.

8. Omphalion height. Omphalion height is an anthropometric measurement, taken while the subject is in an erect standing position, from the floor to the height of the umbilicus.

9. Radiale. The term radiale refers to the distal end of the humerus at the styloid process.

10. Sitting vertex height. Sitting vertex height refers to the height of the vertex, taken while the subject is in an erect sitting position, from a hard-surface chair.

11. Skeletal segment. The term skeletal segment is defined as natural division of body parts in regard to the skeleton.

12. Stylion. Stylion is the distal end of the radius at the styloid process.

13. Styloid process. The styloid process can be defined as a projection or outgrowth of the bone. In this study it is used in regard to the bones of the arm.

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[3]Hoerr and Osol, Blakiston's Illustrated Pocket Medical Dictionary, pp. 752-753.

14. Talo. The term talo refers to the distal end of the tibia just above the talus bone at the ankle joint.

15. Tape. The tape is an accessory in anthropometric measurement. The type used in this study was a Gulick tape with graduations that allow measurement to be taken to an eighth of an inch.

16. Tibiale. Tibiale refers to the distal end of the femur just above the knee joint.

17. Vertex. The vertex is defined as the highest point on the outer surface of the skull.

18. Weight scale. The weight scale used in this study was a Health-O-Meter with graduations that allow measurement to be taken to one-fourth pound.

Need for Study

Certain factors influence all types of physical-performance testing. Many classification systems have been devised to determine or equalize an individual's physical performance according to height, weight, and age distinctions, but differences in skeletal structure are seldom considered. It seems that body proportions in regard to skeletal segments and natural divisions of the body would have an effect on physical performance; however, a significant positive or negative effect was still unknown after studies of related research had been made. On the above-mentioned basis, the investigator attempted to determine whether or not skeletal segments had a relationship to physical-performance items usually included in physical fitness testing of elementary school children.

CHAPTER II

RELATED RESEARCH

Before actively pursuing any study, the investigator became acquainted with related studies in anthropometry and physical performance. Reviews of previous research, as presented in this chapter, served as guidelines in direction and purpose of this study.

For convenience of organization reviews have been divided into three sections as follows: (1) studies of anthropometry, (2) studies of anthropometry and physical performance, and (3) studies of performance.

Studies of Anthropometry

According to Charles B. Davenport: "Anthropometry is the technique of expressing quantitatively the form of the human body."[1] Measurement is the only technique by which the size, form, and proportions of the human body can be expressed accurately.

The object of anthropometry is, as stated by Ales Hrdlicka,

> . . . to supplement visual observation, which is always more or less limited and uncertain, by accurate mechanical determinations. The ideal function of anthropometry would be the complete elimination of personal bias, and the furnishing of absolutely correct data on such dimensions of

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[1]Charles B. Davenport, Guide to Physical Anthropometry and Anthroposcopy, p. 7.

> the body, organs, or skeleton, as might be of importance to those who are to use the measurements.[2]

Anthropometry, as the science of measuring the human body, has been practiced in many fields and for various objectives,[3] including industrial reasons; regulation of art; military selection; medical, surgical, and dental purposes; detection of bodily defects and their correction in gymnastics; criminal and other identification; eugenic purposes; and for scientific investigation.

Originally developed for purposes of art, body proportions were studied so that the ideal form could be portrayed in sculpture or painting. The ancient Egyptians and Greeks developed several canons for the artist to follow in his art expression of the human body,[4] but it was not until the 1800's that anthropometry was seriously considered a science.

During this period A. Quetelet coined the term <u>anthropometry</u> and endeavored to aid its acceptance as a science by classifying and identifying the human races according to their physical proportions. Seaver wrote the following about Quetelet:

> He was the first investigator to apply purely mathematical methods in determining the physical constants of

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[2]Ales Hrdlicka, <u>Anthropometry</u>, p. 7.

[3]<u>Ibid</u>., p. 8.

[4]For a brief review of the canons followed in regard to art expression of the human body refer to Jay W. Seaver, <u>Anthropometry and Physical Examination</u>, pp. 8-10.

the human body, and he demonstrated that the "binomial law," or "law of chance," applied to human proportions. This so-called law of chance, or probability has been found to be true in its general application.[5]

In 1844 Francis Galton proposed to determine the physical constants of English men and women. He grouped all measurements of a particular item into percentile groups and determined the mean which showed that the grouped proportions essentially followed the binomial law.

The law of growth has been presented in various ways using numerical or graphic anthropometry. Seaver stated: "It would seem that the union of the graphic and numerical methods of stating the proportions of an individual must be more comprehensive than either method alone . . ..."[6]

Most methods of presentation rely on the assumption that any group of measurements will adhere to the binomial curve; however, this is not always the case. Causes that prevent the distribution of physical measurements according to the strict law of chance have been attributed to the lack of homogeniety in the data to be tabulated and the lack of uniformity in growth in various periods by Dr. Boas.

Concerning the law of growth, Seaver was of the opinion that a general law of growth could not be applied to all cases, and that

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[5]Seaver, Anthropometry and Physical Examination, p. 11.

[6]Ibid., p. 114.

> even the application of a law determined for any type . . ., has wide limitations, for the relation between bone growth and muscular growth of tall boys is not the same as between the bone and muscle growth of short boys. In the period of accelerated growth from twelve to fifteen years of age the increase of bone lengths is markedly greater than the increase in muscular tissue . . ..
>
> It should also be borne in mind that the rapidity of growth varies in the different sections of the country, apparently according to climatic and telluric conditions.[7]

Schuyler B. Moon of McDonogh, Maryland, conducted a study by grouping the measurements of one hundred and fifteen boys between the ages of thirteen and fourteen years according to Galton's percentile method which demonstrated the "law that while girth measurements are accelerated length measurements are retarded, and _vice versa_."[8]

Perhaps the first indication of applied anthropometry in education was initiated in 1861 by Dr. Hitchcock of Amherst, who established the precedent of a physical examination for students entering the gymnasia. Along with the physical examination, measurements of some items were taken on the men and these data later used to publish tables of averages and means for men sixteen to twenty-five years of age.[9]

The law of growth of Anglo-Saxon children between the ages of five and sixteen was the result of an extensive study made

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[7] Seaver, _Anthropometry and Physical Education_, p. 119.

[8] _Ibid._, p. 121.

[9] This paragraph and the two following it have been paraphrased from Seaver, _Anthropometry and Physical Examination_, pp. 13-15.

of the growth of American school children by Dr. Bowditch in 1887.

Numerous other studies relative to the law of growth have been conducted. To mention a few, Dr. W. T. Porter confirmed the conclusions reached by Bowditch and established several new facts pertaining to the growth of children; Dr. D. A. Sargent began the systematic measurement of students and published percentile tables for men and women for various years of college life; and Dr. W. W. Hastings published a "Manual for Physical Measurements" for boys and girls based on his study of growth of the human body from the ages of five to twenty-one.

Differences in body build were noted before 400 B.C. by Hippocrates, who distinguished two types, namely the short-thick and the long-thin. "Halle in 1797, recognized four types: abdominal, muscular, thoracic (long chest, slender), and nervous (cephalic). Rostan, in 1928, also recognized four types: digestive, muscular, respiratory, and cerebral."[10] The classification of individuals according to body build, however, did not receive much attention until Kretschmer defined three body types--the asthenic, pyknic, and athletic.

Due to the work of Kretschmer, considerable attention has been focused on the classification of individuals on the basis of body type. Some of the more notable studies[11] have been made

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[10]Peter V. Karpovich, <u>Physiology of Muscular Activity</u>, p. 247.

[11]These studies may be found in <u>Measurement in Physical Education</u> by Carlton R. Meyers and T. Irwin Blesh, pp. 257-267.

by Sheldon, who identified three distinct body types--endomorph, mesomorph, and ectomorph; Cureton, who developed a multiple rating scale on the basis of adipose tissue; Wetzel, who developed the Wetzel Grid to evaluate physical fitness in the growth and development of boys and girls; Pryor, for the construction of Width-Weight Tables for both sexes aged one to forty-one; Ludlum and Powell, for development of the Wellesley Weight Prediction method; Meredith, for devising a physical-growth record for boys and girls aged four through eighteen; Franzen and Palmer, for development of the ACH Index; and Sontag and Reynolds for construction of the Fels Composite Sheet for recording and interpreting growth and development.

Davenport[12] describes sixty-nine anthropometric measurements that can be taken on the human body. To take all of these measurements, he states, is time-consuming and often tiresome for the subject; therefore, the essential measurements that are taken will depend on the end sought. In the case of developmental studies he suggests the following individual measurements: weight, standing vertex height, suprasternale height, omphalion height, symphysion height, span, sitting vertex height, and sitting suprasternale. For segments of appendages right acromion height, right radiale height, right stylion height, dactylion height, iliocristale

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[12]Davenport, Guide to Physical Anthropometry and Anthroposcopy, pp. 14 ff.

height, tibiale height, internal malleolus, acromion-stylion length, and acromion-radiale length are the measurements suggested.

In regard to leg length, Davenport ascertains that the real leg length is the distance from the sole of the foot to the axis of the acetabulum, but states that the distance can not be measured accurately on a living subject.

Concerning segments of the arm, he states:

> The segments are measured by differences of height of the different points from floor. They are measured, also, directly as a check. Since most persons can not stretch out the arm perfectly straight, without an angle at the elbow, the direct measurement of acromion-radiale tends to exceed the projective difference by an average of about 5 millimeters; and even the direct measurement acromion-stylion exceeds the projective measurement by about 2 mm., on the average.[13]

In a review of anthropometric measurements, Johnson[14] lists the following as the linear measurements most commonly taken: height, trochanteric height, tibial height, sphyrion height, sitting height, sitting height to suprasternal notch, sitting height to seventh cervical vertebra, forearm length, upper arm length, shoulder width, elbow width, foot length, hand length, and others.

The question of subjects for anthropometric measurements has been considered by Hrdlicka relative to the selection,

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[13]Davenport, Guide to Physical Anthropometry and Anthroposcopy, p. 50.

[14]Warren R. Johnson, Science and Medicine of Exercise and Sports, p. 43.

number, and grouping of subjects. Relative to selection, he states that the value of the data collected will be directly proportional to the purity of the group. Some factors that may influence the data collected are the sex, age, homogeneity, pathological conditions, and, in some cases, occupation, social status, and environmental distinctions of the group. Concerning the number of subjects, a sufficient number should be obtained so that a true picture of the population is represented. When grouping subjects by age, Hrdlicka explains,

> This will be guided by precedence and what may be called the scientific sense. In series of ample size, the segregation up to 6 weeks of age should be by weeks, from that on up to 1 year, by months. From 1 and up to 3½ years, by half a year; and thereafter by the year.[15]

The preceding studies have been reviewed by the author so that an understanding of and a working knowledge of the field of anthropometry could be established.

Studies of Anthropometry and Physical Performance

Barrow and McGee[16] affirm that a relationship exists between age, height and weight, and performance in physical education activities. In recognition of this fact, McCloy[17] and

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[15]Hrdlicka, Anthropometry, p. 43.

[16]Harold M. Barrow and Rosemary McGee, A Practical Approach to Measurement in Physical Education, p. 426.

[17]C. H. McCloy, The Measurement of Athletic Power, p. 94 ff.

Cozens[18] have developed perhaps two of the best known classification systems based on age, height, and weight. McCloy's Classification Index was found to correlate .664 with performance in track and field activities. Significant findings of his research include:

> 1. Chronological age is an important contributing factor up to and including the age of seventeen.
>
> 4. Height at ages of fourteen and below seems to contribute very little--when several events are combined--that is not adequately cared for by age and weight. In the case of individual events, however, height has significance at age levels below this.
> 5. Weight is of great significance at ages of fourteen and below, ...[19]

Even though classification according to one of these two methods would tend to equalize competition, both of these methods fail to consider body type. As a result, Wetzel[20] has developed a Grid that may be used to classify students according to age, height and weight, and body physique.

Using college men, Cozens[21] conducted a study of stature in relation to physical performance. Results of his study indicated that both added height and added weight were assets in

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[18] Meyers and Blesh, Measurement in Physical Education, pp. 312-314.

[19] McCloy, The Measurement of Athletic Power, pp. 94-95.

[20] Barrow and McGee, A Practical Approach to Measurement in Physical Education, p. 427.

[21] Frederick W. Cozens, "A Study of Stature in Relation to Physical Performance," Research Quarterly, I, March, 1930, pp. 38-45.

performance as the tall men and the medium men were superior to the short men, and the heavy men were superior to those who were slender.

According to Morehouse and Miller, "Variations in the position of the muscular attachments, the structure of the joints, and the length of the bony levers all affect the performance of physical activity."[22]

In 1821 Sargent noted that "variations in stature or total height, sitting height, height of knee, and relative length of trunk and limbs, tend to favor different classes of athletic performers."[23]

A study to determine the relationship of physique and developmental level to physical performance of junior high school boys was conducted by Wear and Miller. They observed that

> Individual differences in long-leggedness or long-armedness are just about as much specific to the particular limb under consideration as they are characteristic of the tallness or shortness of the individual, or the longness or shortness of his upper (or lower) limb.[24]

By classifying boys according to ratings on the Wetzel Grid and administering the test items pull-ups, 50 yard dash, standing broad jump, and the softball throw, Wear and Miller concluded

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[22]Laurence E. Morehouse and Augustus T. Miller, Physiology of Exercise, 4th Ed., p. 279.

[23]D. Sargent, "The Physical Test of a Man," School and Society, Vol. 13, January, 1921, p. 130.

[24]C. L. Wear and Kenneth Miller, "Relationship of Physique and Developmental Level to Physical Performance," Research Quarterly, XXXIII, December, 1962, pp. 615-631.

that boys in the heavy-physique group were the poorest performers.

Watson[25] found a very low relationship between nineteen anthropometric measurements representative of body build and the ability of college women to throw a baseball accurately and for distance.

Mathews, Shaw, and Woods[26] tested 158 boys in grades three through six to determine the relationship of hip flexibility and standing reach, standing height, and distance from the greater trochanter to the floor. They found an objectivity coefficient of .98 in measurement of the greater trochanter to the floor. No significant relationship was found between the measurements and hip flexivility as determined by the Wells Sit-and-Reach Test and the Adapted Kraus-Weber Floor-Touch Test.

Beall[27] investigated the relationship of anthropometric measurements, taken on women from five colleges, to success in basketball, swimming, tennis, and modern dance. Using successful and unsuccessful performers in each of the above-mentioned

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[25]Katherine G. Watson, "A Study of the Relation of Certain Measurements of College Women to Throwing Ability," Research Quarterly, VIII, October, 1937, pp. 131-141.

[26]Donald K. Mathews, et. al., "Hip Flexibility of Elementary School Boys as Related to Body Segments," Research Quarterly, XXX, October, 1959, pp. 297-302.

[27]Elizabeth Beall, The Relation of Various Anthropometric Measurements of Selected College Women to Success in Certain Physical Activities, passim.

activities, Beall found specific structural characteristics relative to successful performance as follows:

> Successful basketball players significantly exceed the unsuccessful players in length of upper arm, length of hand, length of entire arm, length of foot, breadth of foot, and breadth of shoulders.
>
> Successful swimmers show a marked difference from the unsuccessful swimmers in six measurements--they weigh more, have broader hands, shoulders, and hips, deeper chests, and a larger chest circumference.
>
> Successful tennis players are taller, have longer trunks and legs, and broader feet than the unsuccessful players.
>
> Modern dance is the only activity in which the unsuccessful group exceeds the successful group in any measurement. Apparently long upper arms and thighs are detrimental to skill in the dance.[28]

Although a representative body build was not identified for any of the four activities, the results found indicated that a majority of the skilled performers possessed certain specific skeletal measurements relative to their success in an activity. Beall concludes that the use of structural measurements as a means of guiding a student in the selection of physical activities cannot be justified because of the numerous measurements that need to be taken; however, she states that a student's achievement in a given activity may be limited or favored by skeletal structure.

Bowne,[29] using 42 high school girls chosen at random,

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[28]Ibid., pp. 48-49.

[29]Mary E. Bowne, "Relationship of Selected Measures of Acting Body Levers to Ball-Throwing Velocities," Research Quarterly, XXXI, October, 1960, pp. 392-402.

found no significant relationship between ball-throwing velocities and body levers contributing to throwing.

Broer and Galles[30] conducted a study to find the importance of the relationship of trunk-plus-arm length (reach) to leg length in ability to perform the toe-touch test. Using 100 college women, they found that reach length to leg length was not significant for subjects of average body build. At the .05 level of confidence the correlation of .22 between the toe-touch test and reach to leg ratio was significant. Subjects having longer trunks and arms in relation to shorter legs seemed to have an advantage in performance. The correlation of -.24 found between leg length and toe-touch indicated that students with shorter legs had an advantage on the toe-touch test. In concluding, the authors made a recommendation that a similar study be conducted with adolescent boys because of their likelihood to have long legs in relation to their trunks.

Three studies were conducted by Clarke,[31] who used 62 male college students to determine the relationship of arm strength to anthropometric measurements. In the third study, two linear

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[30]Marion R. Broer and Naomi R. G. Galles, "Importance of Relationship Between Various Body Measurements in Performance of the Toe-Touch Test," Research Quarterly, XXIX, October, 1958, pp. 253-263.

[31]H. Harrison Clarke, "Relationship of Strength and Anthropometric Measures to Various Arm Strength Criteria," Research Quarterly, XXV, May, 1954, pp. 134-143.

measurements--standing height and length of upper arm--were included among the experimental variables. In general, fairly low correlations were found for standing height and length of upper arm when compared with correlations obtained between the girth of flexed-tensed upper arm and arm strength criteria of the following: Roger's Arm Strength; McCloy's formula for pull-ups, push-up, and for pull-ups plus push-ups; and the MacCurdy pulling test. A correlation of .30 between upper arm length and girth of flexed-tensed upper arm indicated some relationship between these two variables. Because standing height was prominent in the multiple correlations, Clarke concluded that this measurement adds significantly to an individual's ability to perform well on arm-strength measures.

In another study by Clarke,[32] fifty-three unselected male college students were used to determine the relationship of strength and anthropometric measures to physical performances involving the trunk and legs. Among the trunk and leg criteria were the leg lift, standing broad jump, and sit-ups for two minutes. Significant correlations were found for leg lift and the standing broad jump with the anthropometric variables: weight, thigh circumference, calf circumference, subcutaneous tissue over abdomen, and subcutaneous tissue over ilium. The

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[32] H. Harrison Clarke, "Relationships of Strength and Anthropometric Measures to Physical Performances Involving the Trunk and Legs," Research Quarterly, XXVIII, October, 1957, pp. 223-232.

anthropometric variables standing height, leg length, and hip width had significant correlations with the leg lift. All the significant correlations mentioned here between the standing broad jump and anthropometric variables were negative. None of the correlations found between sit-ups for two minutes and anthropometric variables were significant at the .05 level of confidence.

Tomaras[33] conducted a study using twelve, thirteen, and fourteen year-old boys in which he found correlations of .81 and above between anthropometric measurements of body weight, standing height, and sitting height with the criteria of McCloy's pull-ups and McCloy's push-ups. Leg length was found to correlate .71 with pull-ups and .70 with push-ups. Intercorrelations between the anthropometric variables of standing height with sitting height, .94; weight with sitting height, .82; weight with standing height, .82; leg length with weight, .73; and leg length with standing height, .95; were found.

Studies of Performance

Morehouse and Miller[34] report that variations in structure due to age, sex, body type, and race may affect performance.

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[33] William Andrew Tomaras, "The Relationship of Anthropometric and Strength Measures of Junior High School Boys to Various Arm Strength Criteris," p. 66.

[34] Paraphrased from Morehouse and Miller, Physiology of Exercise, 4th Ed., p. 275.

Persons who have significant differences in structure may all be able to perform the same kind of movement, but the quality of the movement is affected by the strength, speed, skill, and endurance that each person possesses. Individuals in a population cannot be differentiated by work that requires only a low grade of organic function, but when the work is increased in intensity or complexity differences among persons become apparent.

As stated by Morehouse and Miller:

> . . . structure modifies activity. The differences in inherent structure affect the performance of work and sport. A linear person is at a disadvantage in performing work and sport that require the carrying of heavy loads or the receiving of body blows. Persons with a lateral body build yield to those with a linear body build in the performance of activities requiring a wide range of movement.[35]

Among other factors, performance may be influenced by height and weight. In the case of height, the taller person's center of gravity is always farther from his base of support. McCloy[36] states that height would be an advantage in events like the high jump because the center of weight is raised from the ground to begin with and the only requirement necessary to gain this advantage is that the person lift his legs out of the way. In events requiring displacement of the center of gravity, the taller person will have a greater displacement than a

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[35] Ibid., p. 279.

[36] Refer to C. H. McCloy, The Measurement of Athletic Power, p. 66.

shorter person and will require more muscle activity. In regard to weight, Morehouse and Miller state, "The heavier the weight of a person in relation to his musculature, the greater the limitation of his physical skill. Added weight in the form of fat increases the effort needed to perform a movement."[37] Furthermore, these authors affirm that

> Various types of competitive athletics require different proportions of fat to muscle for maximum performance. A minimum amount of fat is desirable in a distance runner, a high jumper, and a gymnast. These athletes must move their own weight in a highly economical fashion, and any added weight taxes the strength and endurance.[38]

Adipose tissue that a person possesses as well as differences in basal metabolism can be limiting factors in performance. All the factors mentioned and numerous others may limit or enhance performance depending on the activity performed; however, an examination of these factors and the influence they may exert on performance would be too lengthy to include in these reviews.

Studies of performance have shown that "In bursts of all-out exercise, man reaches his maximal rate of energy output within a few seconds and can maintain this rate for twenty or thirty seconds. Thereafter, the rate falls off."[39] In an

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[37] Morehouse and Miller, Physiology of Exercise, 4th Ed., p. 52.

[38] Ibid., p. 207.

[39] Johnson, Science and Medicine of Exercise and Sport, p. 385.

analysis of strength tests, Fleishman[40] states that no separate factor of muscle endurance distinguishes performance carried to "limit" from shorter timed versions of the same test.

The investigator examined some of the more widely-used physical fitness tests for girls between the ages of ten and eleven to determine the items that were commonly included in these tests. Reviews of these tests are presented below.

The Kraus-Weber Tests for Muscular Fitness[41] was one of the first tests that focused attention on the fitness of youth. Items included in this test are sit-ups, bent-knee sit-ups, leg lift, reverse sit-up, reverse leg lift, and standing toe touch.

The AAHPER Youth Fitness Test[42] includes the following test items for girls: modified pull-ups, sit-ups, shuttle run, standing broad jump, 50-yard dash, softball throw, and 600-yard run-walk.

The North Carolina Fitness Test[43] includes the following fitness items: sit-ups, side-stepping, standing broad jump, modified push-ups, and squat thrust.

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[40]Refer to Edwin A. Fleishman, The Structure and Measurement of Physical Fitness, p. 70.

[41]Hans Kraus and Ruth P. Hirshland, "Minimum Muscular Fitness Tests in School Children," Research Quarterly, XXV, May, 1954, pp. 178-187.

[42]AAHPER, Youth Fitness Test Manual, 1961, passim.

[43]This fitness test and the two following it were reviewed in Barrow and McGee, A Practical Approach to Measurement in Physical Education, pp. 218 ff.

The Indiana Physical Fitness Tests include straddle chins, push-ups, squat thrust, and vertical jump.

The New York State Physical Fitness Test includes the following items: posture test, target throw, modified push-ups, modified pull-ups, side-stepping, 50-yard dash, squat stand, and treadmill test.

Fleishman's basic fitness test[44] includes these items: extent flexibility, dynamic flexibility, shuttle run, softball throw, hand grip, pull-ups, leg lifts, cable jump, balance A, and the 600-yard run-walk.

A brief perusal of other fitness tests[45] and the ones reviewed here indicate that, as a general rule, the standing broad jump, push-ups, pull-ups, sit-ups, leg lifts, shuttle run, 50-yard dash, softball throw, and an endurance test are items commonly found in physical fitness test batteries.

In conducting a study on the performance of fourth-, fifth-, and sixth-grade students, Latchaw[46] found no significant differences between the means of fourth- and fifth-grade girls and fifth- and sixth-grade girls in the standing broad jump.

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[44]Refer to Fleishman, The Structure and Measurement of Physical Fitness, passim.

[45]Other fitness tests may be reviewed in the book by Meyers and Blesh, Measurement in Physical Education, Chapter 8, "Testing Strength and Motor Fitness," pp. 222-230.

[46]Marjorie Latchaw, "Measuring Selected Motor Skills in Fourth, Fifth, and Sixth Grades," Research Quarterly, XXV, December, 1954, pp. 439-449.

CHAPTER III

PROCEDURES

Preliminary procedures included the selection of subjects, anthropometric measurements, and performance items.

Selection of subjects. Through the cooperation of the San Marcos Independent School District, 102 ten- and eleven-year old girls were selected from Bowie and Travis Elementary Schools in San Marcos, Texas. Subjects were selected because of their proximity to the investigator's base of operations, because they had similar programs of physical education from which subjects were drawn for the purpose of testing, and because they showed no apparent defect that would influence performance. Subjects were drawn from two schools because a single school could not provide a sufficient number of subjects for the collection of data.

Selection of anthropometric measurements. The anthropometric measurements used in this study were chosen according to Davenport's suggested measurements for developmental studies and Johnson's list of linear measurements commonly taken in anthropometric studies. The investigator selected measurements that were believed to be suitable and pertinent to this study as well as practical in terms of time and accuracy of measurement. Anthropometric measurements selected were weight, standing vertex height, omphalion height, acromion-dactylion length, acromion-stylion length, acromion-radiale length, greater trochanter-tibiale length, tibiale-talo length, and sitting vertex height. In the initial selection of measurements suprasternale height was included but disregarded before the collection of data was begun because the author assumed this measurement would be embarrassing to girls of this age due to the nature of the measurement. The method of taking leg-length measurements was devised by the author in order to provide a direct measurement of the segment rather than one from the floor so that arm-segment measurements and leg-segment measurements would be taken in the same manner.

Selection of test items. The final items in the test battery were selected on the basis of the reviews of items commonly included in fitness testing presented in Chapter II, by logical analysis of the exercises representative of those employed in physical education fitness-testing programs in the schools and by the recommendations made by Broer and Galles relative to the Toe-Touch test. Items were also selected according to the practical considerations of time, facilities, and equipment. The test items chosen were sit-ups, bent-knee sit-ups, modified pull-ups, modified push-ups, leg lifts, toe touch, toe touch - toes pointed, and the standing broad jump. With the exception of the standing broad jump, the investigator decided to time all items for 30 seconds on the basis of Johnson's and Fleishman's statements regarding maximum output and muscle endurance as cited in Chapter II.

Test Preparations. Preparations for testing included calibration of the stop watch and the Guilick tape and the selection of testing personnel.

The stop watch was calibrated by placing it and three other wound watches of the same make in grooves in a wooden box with a hinged lid. By applying a downward pressure to the lid, this device is capable of starting and stopping all watches simultaneously. After one minute had elapsed watches were stopped by pressure on the lid and all watches showing the same exact time were assumed to be accurate. The Guilick tape was tested for accuracy to the last 1/8 inch by means of observation in measuring it with two steel tapes.

Because of time conflicts, only one person was available to aid the investigator for a limited portion of performance testing. This person was thoroughly acquainted with the test items and administrative procedures that the investigator wished to follow.

Anthropometric Measurement of Subjects. All subjects were measured without shoes, coats, or sweaters. With the exception of weight, all measurements were taken to the last 1/8 inch. Each anthropometric measurement was recorded on the individual's combination measurement and performance chart (see Figure 1). Anthropometric measurements were taken as follows:

1. <u>Weight</u>. The subject stood straight with both feet flat on the scale and weight evenly distributed. Weight was taken to the last one-fourth pound.

2. <u>Standing vertex height</u>. The subject stood erect with arms straight, palms flat at sides of legs, feet together, and weight evenly distributed. The distance of the vertex from the floor was measured to the last one-eighth inch by adjusting the stadiometer so that it came in contact with the vertex.

3. <u>Omphalion height</u>. The subject assumed the same position used in 2. Measurement was made from the floor to the center of the umbilicus with the Gulick tape. The umbilicus was located by means of palpation.

4. <u>Acromion-dactylion length</u>. This measurement gave the total length of the arm segment. Measurement was made on the left side of the body with the Gulick tape. The subject stood in the same position described in 2, arms held in contact with thighs. The subject raised her arm so that the glenoid cavity could be found and the superior external border of the acromion was located by palpation. Measurement was taken from this position to the extreme distal end of the middle finger, excluding the fingernail. The investigator reminded the subject to remain standing erect during the measurement.

5. <u>Acromion-stylion length</u>. The same procedures used in 4 were followed, but measurement was made from the acromion to the distal end of the radius at the stylion, located by palpation. This measurement gave the length of the arm from acromion to the radius.

6. Acromion-radiale length. Using the same procedures followed in 4, measurement was taken from the acromion to the distal end of the humerus at the stylion. This gave the length of the humerus.

7. Greater trochanter-tibiale length. This measurement gave the length of the femur. As the subject sat on a chair with knees flexed, the head of the greater trochanter was located by having the subject extend her lower leg and return it to the floor so that this point could be found by palpation. The distance was measured from the greater trochanter to the distal end of the femur. The distal end of the femur is located behind the lower third of the patella and was found by palpation.

8. Tibiale-talo length. The subject was in the same position used in 7, but measurement was made by palpation from the proximal end of the tibia to the distal end of the tibia just above the talus at the ankle joint.

9. Sitting vertex height. After the eighth measurement had been taken, the subject moved forward so that the height of the vertex from the surface of the chair could be taken. The measurement taken gave the sitting vertex height.

Administration of Test Items. In order to obtain accurate scores it was important that all subjects knew how to perform the selected test items. Before the administration of a test item the investigator demonstrated the exercise to be performed. Questions asked by subjects in regard to the performance of the exercise were answered. Because the element of time did not allow the performance of all items on the same day, sit-ups were administered at the beginning of the period and bent-knee sit-ups were administered at the close of the period on the first day. Leg lifts were administered on the second day. All scores were recorded on the measurement and performance chart (see Figure 1). With the exception of the standing broad jump all items were timed for 30 seconds. The test items were administered according to the following directions:

1. Sit-ups. The subject lay on her back on a gym mat with hands clasped behind her head with legs straight and with feet approximately twelve inches apart. An adjustable door bar was placed across the subject's ankles to keep her heels in contact with the floor during performance. At the signal, "GO," the subject raised her back from the floor and came to a sitting position, as described, a count was given. The total number of sit-ups performed was the subject's score.

2. Bent-Knee Sit-ups. The procedures and method of scoring were the same used in 1 except that the subject's knees were bent and the adjustable bar was placed under the subject's knees to keep the legs from straightening during performance. Feet were held in contact with the floor by the investigator.

3. Modified Pull-ups. Directions for this test were taken from the New York State Physical Fitness Test.

> The girl should grasp the bar with her palms facing upward and slide her feet under the bar until her body and legs are completely extended with the arms now at an angle of 90 degrees with the chest. The legs and body should comprise a straight line and form an angle of approximately 45 degrees with the floor with the weight of the body resting on the heels. The feet of the student can be braced to prevent slipping by the scorer placing her foot sideways under the insteps. From this position the girl pulls up with her arms until they are completely bent and her chest touches the bar or rung. She then returns to the starting position and repeats as many times as possible.[1]

Resting was not allowed. The subject's score was the total number of correct pull-ups.

4. Modified Push-ups. Directions for this item were followed according to the directions for push-ups for girls, Item Number III found in the Indiana Physical Fitness Tests.

> The student assumes a starting position by lying prone on the floor. The knees are bent at right angles and the hands are on the floor directly beneath the shoulders. The body is pushed up by means of straightening the arms and the body remains in a straight line position. This is the push-up position and is followed by a lowering of the body until the chest touches the floor. This cycle is repeated as many times as possible.[2]

The only change made in administration of this item was that the subject lay on a gym mat instead of the floor. Resting was not permitted. The total number of correct push-ups was the subject's score.

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[1]Barrow and McGee, A Practical Approach to Measurement in Physical Education, pp. 241-242.

[2]Ibid., pp. 220-221.

5. Leg Lifts. The subject lay on her back on a gym mat, palms down, arms at sides. The investigator held the subject's shoulders just below the arm pits close to the floor. Keeping her knees straight and legs together, the subject raised her legs until they were perpendicular to the floor. She lowered her legs to the floor in the same manner. Care was taken not allow the legs to drop. The number of times the subject lifted her legs correctly was the subject's performance score.[3]

6. Toe Touch. The subject was in a sitting position on a gym mat, hands on hips, legs straight, and feet approximately twelve inches apart. At the signal, "GO," the subject touched the right hand to the toes of the left foot and then returned her hand to her hip. The second time the exercise was performed, the subject touched her left hand to the toes of her right foot. This exercise was repeated as many times as possible, alternating left and right toe touches. The subject's score was the total number of correct toe touches.

7. Toe Touch - Toes Pointed. The same procedures and scoring method used in 6 was followed except the subject kept the feet extended and the toes pointed.

8. Standing Broad Jump. Directions were the same as those given by Fleishman with the following exceptions: The subject could stand anywhere behind the start line and a rubber door mat was used for the take-off.

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[3]Paraphrased from Henrietta H. Avent, Tests of Static and Dynamic Strength, p. 49.

> The subject put his toes up to a start line and then jumped as far forward as possible. The jump was performed on a mat marked off in two inch units. He was allowed to do anything with his arms. He was told that if he fell backwards the jump would not count. Score was the best jump out of three, as measured from the start line to the rear of the foot closest to the start line at impact.[4]

Method for Analysing Results. By means of rank-order correlation, the relationship between anthropometric measurements and the physical-performance items set forth in this study was determined. It must be remembered that the correlation technique of rank-differences takes into account only the position of an item in a series and no allowance is made for gaps between scores. Translation of scores into ranks, especially when there are a number of ties, may result in a loss of accuracy.[5] The hypothesis that there was no correlation between the item and the anthropometric measurement was tested in each case.

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[4]Fleishman, The Structure and Measurement of Physical Fitness, p. 49.

[5]Paraphrased from Henry E. Garrett, Statistics in Psychology and Education, p. 375.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF THE DATA

In order to determine the type of correlation method that could be used in calculation of the data, the investigator needed to know whether or not performance scores were normally distributed. Using performance scores made on the item of sit-ups, the Chi-square Test for Goodness of Fit[1] was applied. Results indicated the absence of a normal distribution which eliminated those methods of correlation having this requirement.

The next step was to determine whether or not weight was a factor in performance by using the Spearman Rank-Difference method of correlation. Weight was found to be a factor, according to Garrett's method for testing the significance of Rho,[2] in performance scores made on the items of modified pull-ups and leg lifts at the .05 level of confidence, the correlation coefficients being -.22 and -.30, respectively. Weight was found not to be a factor in performance scores made on other items.

The investigator did not consider age to be a factor in the performance scores of ten- and eleven-year old girls in this study.

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[1]E. F. Lindquist, Statistical Analysis in Educational Research, pp. 37-41.

[2]Garrett, Statistics in Psychology and Education, p. 375.

Anthropometric measurements and performance scores were arranged in descending order and ranked according to the Spearman Rank-Difference Correlation Method. In the case of tied ranks average rank values were assigned. Weight was found to be a factor in performance scores made on modified pull-ups and leg lifts; therefore the data for these items were first arranged in weight groups having an interval of ten pounds, and the rank-difference calculated for each group according to the same procedures used for the other items. Correlation coefficients to determine the relationship of anthropometric measurements to physical-performance items were found according to the formula:

$$\rho = 1 - \frac{6\ D^2}{N(N^2 - 1)}$$

In each case the hypothesis that there was no correlation between the item and the anthropometric measurement was tested. Results are presented in Table I.

Weight was found to be a significant negative factor in the performance of modified pull-ups and leg lifts with correlation coefficients of -.22 and -.30, respectively. Subjects who have less weight are more likely to score higher in the performance of modified pull-ups and leg lifts; however, when correlations were calculated for these items according to weight groups, significant negative correlations were found to exist only for the weight group 63-44 pounds (n=27). The correlation between weight and modified pull-ups in this weight

TABLE I

TABLE OF RANK-ORDER CORRELATIONS

Criteria	Anthropometric Measurements[a] I	II	III	IV	V	VI	VII	VIII	IX
Sit-ups	-.01	.24[b]	.18	.18	.16	.24[b]	.07	.16	.06
Bent knee sit-ups	-.08	.20[b]	.20[b]	.18	.21[b]	.26[b]	.03	.16	.12
Modified pull-ups	-.22[b]								
94 and above	-.10	.19	.17	.00	.12	.08	-.09	-.10	.53[b]
84 to 93	-.34	-.23	.05	-.03	-.09	-.16	-.23	-.12	.00
74 to 83	-.24	-.03	.02	-.04	.02	.26	-.20	-.37	.02
64 to 73	-.28	.15	.04	.09	.06	.55[b]	.19	.27	-.25
63 and below	-.54[b]	-.07	-.07	-.23	-.26	-.08	.03	-.33	-.27
Modified push-ups	.09	.18	.09	.07	.13	.18	.06	.09	.05
Leg lifts	-.30[b]								
94 and above	-.13	-.06	.19	.04	-.06	.11	.12	-.12	.08
84 to 93	.09	-.04	.11	.01	.05	.06	.32	-.24	.03
74 to 83	-.08	.09	.11	.17	.15	.25	-.37	.30	.19
64 to 73	-.32	-.20	-.15	-.39	-.39	-.07	.12	-.24	.10
63 and below	-.57[b]	.20	.21	.17	.19	.29	.18	.10	-.26
Toe touch	-.01	-.08	-.12	-.10	-.06	-.02	.03	-.09	-.10
Toe touch - toes pointed	-.10	-.14	-.16	-.15	-.09	-.09	-.60[b]	-.05	.02
Standing broad jump	-.13	.33[b]	.31[b]	.35[b]	.33[b]	.37[b]	.08	.25[b]	.17

[a]Anthropometric measurements are identified as follows: I. Weight, II. Standing vertex height, III. Omphalion height, IV. Acromion-dactylion length, V. Acromion-stylion length, VI. Acromion-radiale length, VII. Greater trochanter-tibiale length, VIII. Tibiale-talo length, IX. Sitting vertex height.

[b]Significant at the .05 level of confidence according to Garrett, Statistics, Table 25.

group was -.54, and the correlation between weight and leg lifts was -.57.

Standing vertex height was significant at the .05 level of confidence when correlated with the performance of sit-ups, bent-knee sit-ups, and standing broad jump. Correlations of .24, .20, and .33 respectively with body height indicate that tall subjects are more likely to have high performance scores on these items.

The height of the omphalion was significant when correlated with scores made on bent-knee sit-ups and the standing broad jump. The correlations of .20 between omphalion height and bent-knee sit-ups and .31 between omphalion height and standing broad jump indicate that greater omphalion height would enable subjects to perform a greater number of bent-knee sit-ups and to jump a farther distance in the standing broad jump than subjects whose omphalion is closer to the floor.

Only one significant correlation coefficient was found between acromion-dactylion length and performance items. The correlation of .35 found between this anthropometric measurement and the standing broad jump indicates that subjects having longer arms, including the length of the hand, are able to jump a greater distance than subjects with shorter acromion-dactylion length.

Acromion-stylion length was a significant factor in the performance of bent-knee sit-ups (.21) and the standing broad jump (.33). Results indicate that subjects having longer arm length, excluding the length of the hand, make higher performance scores on these two items than subjects having a shorter distance from acromion to stylion.

The relationship of acromion-radiale length was significant with four performance items which were sit-ups (.24); bent knee sit-ups (.26); modified pull-ups, only in the 64 to 73 pound weight group (.55); and the standing broad jump (.37). Subjects with greater acromion-radiale length are more likely to score high on the above-mentioned performance items according to the correlations found.

Of the sixteen correlations calculated between greater trochanter-tibiale length and performance items, only one was significant at the .05 level of confidence. The relatively high correlation of -.60 between toe touch - toes pointed with greater trochanter length indicates that subjects whose greater trochanter length is short have an advantage in the performance of this item.

The correlation of tibiale-talo length with the standing broad jump signifies that subjects who had the greatest tibiale-talo length were the best performers of this item. The correlation coefficient was .25.

A correlation of .53 was found between sitting vertex height and modified pull-ups for subjects in the 94 to 113.5 pound weight group only (n=15). This correlation coefficient indicates that the highest scores on modified pull-ups by subjects in this weight group were made by those who had the greatest sitting vertex height.

The data from Table I may be more easily understood and interpreted by considering the specific items of performance that were influenced by one or several of the anthropometric measurements.

Performance scores that were made on the item of sit-ups were influenced by the measurements of standing vertex height and acromion-radiale length.

In examining the relationship of standing height with sit-ups ($\rho = .24$), it may be conjectured that subjects who were taller had less body mass than shorter subjects; therefore shorter subjects had more body mass to lift and might not be able to perform as many sit-ups as taller subjects. Although total weight did not have a significant relationship to the performance of sit-ups, a shorter person may have had more torso weight than a taller person which would have given the taller person an advantage in the performance of sit-ups; but it seems that if this were true, the anthropometric measurement of sitting vertex height would have had a significant relationship with sit-ups. Neuromuscular development may have been a factor in performance; if taller subjects had a higher level of neuromuscular development than shorter subjects it is possible that accompanying increases in strength, skill, and speed would add significantly to the ability of the subject to perform sit-ups. Differences in basal metabolism rate among subjects could influence performance on this item. In the event that taller subjects possessed a higher basal metabolism rate, this would imply that taller girls had a higher concentration of active tissue with less in the way of fatty deposits, and taller subjects might have an advantage in the performance of sit-ups.

The effect of acromion-radiale length on the performance of sit-ups (ρ =.24) may indicate that subjects who were weak in abdominal strength needed the added leverage and strength of the upper arm to begin the initial movement. If this possibility happens to be true, the girth of the segment would have a possible influence on this performance. The factors of adipose tissue and neuromuscular development may also influence the scores made.

Anthropometric measurements influencing the performance scores of bent-knee sit-ups include the following: standing vertex height, omphalion height, acromion-stylion length, and acromion-radiale length. The same explanations given for the possibilities of the relationship between standing vertex height and sit-ups may apply to the relationship between standing vertex height and bent-knee sit-ups (ρ =.20).

Omphalion height, a measurement that was not significant with the performance of sit-ups, had a relationship of .20

with bent-knee sit-ups. This might be explained by the fact that in the bent-knee sit-ups the subject was not able to take the full advantage of height. Subjects with less to lift from the floor in terms of height and weight were able to perform more bent-knee sit-ups than a person having the omphalion closer to the ground.

The fact that acromion-stylion length appeared in addition to acromion-radiale length as significant with bent-knee sit-ups performance (ρ =.21 and ρ =.26 respectively) may be due to the nature of the movement. The latter measurement was significant with performance of sit-ups with the legs straight and also with performance of bent-knee sit-ups indicating that the added leverage of the arm was needed in performance. The fact that acromion-stylion length was significant with bent-knee sit-ups, but not with the performance of sit-ups, might indicate that strength of the muscle groups involved in this performance was not sufficient and that the additional strength and leverage of the acromion-stylion had to be facilitated.

Some interesting correlations were found between modified pull-ups and anthropometric measurements. When weight was correlated with modified pull-ups using the single group of all 102 subjects a negative correlation of -.22 was found; but in subsequent correlations made according to weight groups for this item, weight appeared as a significant factor only for the weight group 63 to 44 pounds (ρ =-.54). In considering the correlation coefficient for all subjects as one group, a logical interpretation could be that subjects who weighed more had more body mass to put in motion against the pull of gravity, placing heavier subjects at a disadvantage in performing this item. This would support Fleishman's[3] finding that weight is a negative factor in the performance of dynamic strength items. The fact that weight did not appear as significant with weight groups other than the 63 to 44 pound weight group gives rise to some questions. It is possible that differences in neuromuscular development could account for this finding. Along with weight, subjects in other groups may have had additional increases in strength so that the factor of weight alone would not appear as a significant factor with subjects in higher weight groups. As subjects in the weight group 63 to 44 pounds may not have had corresponding increases in weight and neuromuscular development, it is possible that only the factor of weight would influence the performance of modified pull-ups. Another factor that may have influenced performance so that significant correlations were not found in other weight groups might be differences due to basal metabolism rates.

Acromion-radiale length was a factor in the performance of modified pull-ups (ρ=.55) only for the weight group 64 to 73 (n=15). Factors such as girth, basal metabolism, and others

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[3]Fleishman, The Structure and Measurement of Physical Fitness, p. 64.

may affect performance by subjects in the weight group 64 to 73 pounds.

Sitting vertex height was significant (ρ =.53) only with the weight group 94 to 113.5 pounds in the performance of modified pull-ups (n=15).

None of the anthropometric measurements correlated significantly with modified push-ups.

In the performance of leg lifts, only the factor of weight was significant at the .05 level of confidence. It is interesting to note that a significant correlation (-.30) was found for weight and leg lifts when all subjects were considered in one group, and significant only in the weight group 63 to 44 pounds (ρ =-.57) when calculated according to weight groups because significant correlations of weight and modified pull-ups appeared in the same pattern. It would seem that the possibilities for interpreting the results of the relationship of weight with modified pull-ups might apply in an attempt to interpret the significance of weight with leg lifts.

No significant correlations were found between the performance item of toe touch with anthropometric measurements.

Of the nine anthropometric measurements taken, six were significantly related with performance score made on the stand-broad jump. These six measurements include standing vertex height, omphalion height, acromion-dactylion length, acromion-stylion length, acromion-radiale length, and tibiale-talo length. All correlations were positive, indicating that subjects having greater measurements were the better performers of this item.

The influence of standing vertex height with the standing broad jump (ρ =.33) might logically be explained by the fact that a taller person has a higher center of gravity and may gain an advantage only by moving her legs out of the way, as McCloy has suggested.[4] Taller persons could possibly possess accompanying increases in neuromuscular development and coordination along with height increases.

Omphalion height could influence performance scores on the standing broad jump (ρ =.31) in the same manner that total body height could; that is, the center of gravity for a person with a greater omphalion height would be higher enabling these subjects to jump farther than subjects having a lower omphalion height. A person with less omphalion height would tend to have more mass closer to the ground than a person with a higher omphalion height. Other factors that have been mentioned, including adipose tissue, neuromuscular development and coordination, basal metabolism, and others, could influence performance scores on this item.

Because the anthropometric measurements taken on the arm overlap, the influence of these measurements will be considered together as the whole arm, as well as segments of the arm, were

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[4]Refer to Chapter II, p. 21.

found to influence performance on the standing broad jump. A possible explanation for these findings might be that the added length of the arms is used to help project the body up into the air and away from the starting position by giving added momentum to the movement. Added length of the arms could also supply subjects with a wider range of movement. Other factors, previously mentioned, could influence standing broad jump performance.

A greater tibiale-talo length was an advantage in the performance of the standing broad jump as indicated by the correlation of .25. Possible factors that might account for this relationship are similar to those given for other relationships. In this event; however, if the added length of the segment indicates less weight or girth of the leg, subjects having shorter lower legs would not be able to perform as well as subjects having a greater tibiale-talo length on this item.

The foregoing interpretations must necessarily be confined to the specific anthropometric measurements taken. It should be recognized that such factors as basal metabolism, adipose tissue, gravity, neuromuscular coordination and development, girth, motivation, and others might influence performance on the items used in this investigation. In addition, the limitations imposed by rank-order correlations should be kept in mind.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

It was the purpose of this study to determine the relationship of anthropometric measurements to physical performance items commonly included in physical-fitness testing of ten- and eleven-year old girls.

Nine anthropometric measurements were taken on 102 subjects and their relationship to the criteria of sit-ups, bent-knee sit-ups, modified pull-ups, modified push-ups, leg lifts, toe touch, toe touch - toes pointed, and standing broad jump was calculated by means of the Spearman Rank-Difference Correlation method. A summary of the results is as follows:

1. Six anthropometric measurements had significant relationships to the standing broad jump. These measurements were standing vertex height, .33; omphalion height, .31; acromion-dactylion length, .35; acromion-stylion length, .33; acromion-radiale length, .37; and tibiale-talo length, .25.

2. Four anthropometric measurements had significant correlations with bent-knee sit-ups: standing vertex height, .20; omphalion height, .20; acromion-stylion length, .21; and acromion-radiale length, .26.

3. Two variables, sitting vertex height and acromion-radiale length, had significant correlation coefficients with sit-ups of .24 and .24, respectively.

4. Greater trochanter-tibiale length had a significant correlation coefficient of -.60 with the item of toe touch - toes pointed.

5. No significant correlations were found between the anthropometric measurements taken and the items of modified push-ups and toe touch.

6. The anthropometric measurement of weight was found to have significant negative correlations of -.22 and -.30 with the items of modified pull-ups and leg lifts respectively. On the basis of these correlations, further calculations were made according to weight groups.

a. In the weight group 94 and above (n=15), sitting vertex height correlated .53 with modified pull-ups.

b. In the weight group 64 to 73 (n=15), acromion-radiale length correlated .55 with modified pull-ups.

c. In the weight group 63 and below (n=27), weight correlated with modified pull-ups -.54.

d. In the weight group 63 and below, weight correlated -.57 with leg lifts.

Performance items most affected by a number of anthropometric measurements as taken in this study were the standing broad jump and bent-knee sit-ups.

As a general rule, the better performers of the standing broad jump were those girls who had longer skeletal segments and who were tall in stature as compared to shorter girls who had shorter segments.

In the performance of bent-knee sit-ups, girls who were taller in stature, possessed more omphalion height, and had longer arm skeletal segments made better performance scores than girls who were shorter, possessed less omphalion height, and had shorter arm skeletal segments.

It is interesting to note that in the cases where weight was found to be a factor in performance, the length of skeletal segments was not a factor and conversely.

It is apparent from this study that more research should be conducted in regard to skeletal measurements in the performance of such items as the standing broad jump and bent-knee sit-ups.

On the basis of this investigation the following recommendations are made:

1. Correlations found between modified pull-ups and leg lifts only in the 63-44 pound weight group indicate the need for further research in this area.

2. Significant correlations found in some weight groups but not in others indicate the need for further research.

3. In further studies the number of anthropometric measurements as well as kind of measurements should be increased so that results can be more accurately interpreted.

4. Factors such as basal metabolism rate, girth, and neuromuscular development and coordination should be taken into account in further studies.

5. A similar study of girls age thirteen and fourteen is recommended because by this time most of them have reached the age of puberty.

BIBLIOGRAPHY

AAHPER, Youth Fitness Test Manual, American Association for Health, Physical Education, and Recreation, Washington, d.c., 1961.

Avent, Henrietta Hempstead, Tests of Static and Dynamic Strength for Girls Nine through Twelve Years Old, Unpublished Dissertation, Indiana University, Bloomington, 1963.

Barrow, Harold M., and Rosemary McGee, A Practical Approach to Measurement in Physical Education, Lea & Febiger, Philadelphia, 1964.

Beall, Elizabeth, The Relation of Various Anthropometric Measurements of Selected College Women to Success in Certain Physical Activities, Teachers College, Columbia University, New York City, 1939.

Bowne, Mary E., "Relationship of Selected Measures of Acting Body Levers to Ball-Throwing Activities," Research Quarterly, XXXI (October, 1960).

Broer, Marion R. and Naomi R. G. Galles, "Importance of Relationship Between Various Body Measurements in Performance of the Toe-Touch Test," Research Quarterly, XXIX (October, 1958).

Clarke, H. Harrison, "Relationship of Strength and Anthropometric Measures to Various Arm Strength Criteria," Research Quarterly, XXV (May, 1954).

________. "Relationships of Strength and Anthropometric Measures to Physical Performances Involving the Trunk and Legs," Research Quarterly, XXVIII (October, 1957).

Cozens, Frederick W., "A Study of Stature in Relation to Physical Performance," Research Quarterly, I (March, 1930).

Davenport, Charles B., Guide to Physical Anthropometry and Anthroposcopy, Waverly Press, Baltimore, 1927.

Fleishman, Edwin A., The Structure and Measurement of Physical Fitness, Prentice-Hall, Inc., Englewood Cliffs, 1964.

Garrett, Henry E., Statistics in Psychology and Education, Longmans, Green and Co., New York, 1958.

Hoerr, Normand L. and Arthur Osol, Blakiston's Illustrated Pocket Medical Dictionary, 2nd Edition, McGraw-Hill Book Company, Inc., New York, 1960.

Hrdlicka, Ales, Anthropometry, The Wistar Institute of Anatomy and Biology, Philadelphia, 1920.

Johnson, Warren R., Science and Medicine of Exercise and Sports, Harper & Brothers, New York, 1960.

Karpovich, Peter V., Physiology of Muscular Activity, 6th ed., W. B. Saunders Company, Philadelphia, 1965.

Kraus, Hans, and Ruth P. Hirschland, "Minimum Muscular Fitness Tests in School Children," Research Quarterly, XXV (May, 1954).

Latchaw, Marjorie, "Measuring Selected Motor Skills in Fourth, Fifth, and Sixth Grades," Research Quarterly, XXV (December, 1954).

Lindquist, E. F., Statistical Analysis in Educational Research, Houghton Mifflin Company, Boston, 1940.

McCloy, C. H., The Measurement of Athletic Power, A. S. Barnes & Co., New York, 1932.

Mathews, Donald K., et. al., "Hip Flexibility of Elementary School Boys as Related to Body Segments," Research Quarterly, XXX (October, 1959).

Meyers, Carlton R. and T. Erwin Blesh, Measurement in Physical Education, The Ronald Press Company, New York, 1962.

Morehouse, Laurence E., and Augustus T. Miller, Physiology of Exercise, 4th Edition, The C. V. Mosby Company, Saint Louis, 1963.

Sargent, D. A., "The Physical Test of a Man," School and Society, XIII (January, 1921).

Seaver, Jay W., Anthropometry and Physical Examination, The Curtiss-Way Co., Meriden, 1909.

Tomaras, William Andrew, The Relationship of Anthropometric and Strength Measures of Junior High School Boys to Various Arm Strength Criteria, University of Oregon, Eugene, 1958.

Watson, Katherine G., "A Study of the Relation of Certain Measurements of College Women to Throwing Ability," Research Quarterly, VIII (October, 1937)

Wear, C. L., and Kenneth Miller, "Relationship of Physique and Developmental Level to Physical Performance," Research Quarterly, XXXIII (December, 1962).

APPENDIX

FIGURE 1

ANTHROPOMETRIC MEASUREMENTS AND PHYSICAL PERFORMANCE CHART

Name____

Age____

ANTHROPOMETRIC MEASUREMENTS

MEASUREMENTS

1. Weight ________
2. Standing vertex height ________
3. Omphalion height ________
4. Acromion-dactylion length ________
5. Acromion-stylion length ________
6. Acromion-radiale length ________
7. Greater trochanter-tibiale length ________
8. Tibiale-talo length ________
9. Sitting vertex height ________

PHYSICAL PERFORMANCE

ITEMS

1. Sit-ups ________
2. Bent-knee sit-ups ________
3. Modified pull-ups ________
4. Modified push-ups ________
5. Leg lifts ________
6. Toe touch ________
7. Toe touch - toes pointed ________
8. Standing broad jump ________

Note: Items 1 through and including 7 are timed for 30 seconds.