1972

The Relationship of Jump Shooting Ability in Basketball to Selected Measurable Traits

Donald F. Dahl

THE RELATIONSHIP OF JUMP SHOOTING
ABILITY IN BASKETBALL
TO SELECTED MEASURABLE TRAITS

BY

DONALD F. DAHL

A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Physical Education, South Dakota
State University

1972

THE RELATIONSHIP OF JUMP SHOOTING ABILITY IN BASKETBALL TO SELECTED MEASURABLE TRAITS

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor   Date

Head, Health, Physical Education and Recreation Department   Date

ACKNOWLEDGEMENTS

The investigator would like to express sincere thanks to Dr. Paul Brynteson and Professor Glenn E. Robinson for their guidance and assistance in developing and writing this thesis.

A special thanks to Dr. Lee W. Tucker, Associate Professor of Agriculture and Biological Sciences for his valuable statistical assistance.

The cooperation and tolerance exhibited by my wife, Kay, and my son, Brian, were also greatly appreciated. Also a special thank you to my wife Kay, for her long hours at the typewriter.

DFD

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

CHAPTER I

INTRODUCTION

Significance of the Study

The game of basketball has undergone changes over the years and today it is a fast moving game wherein all of the players have an opportunity to score. The very nature of the game indicates that accurate shooting is essential to the final outcome.

Sharmin stated the obvious, that in basketball, the team which wins scores more points than its opponent, and "Accurate shooting is the backbone of the game."[1] This idea is supported by Benington and Newell who stated that "The skill of shooting has probably developed more than any other aspect of the game of basketball."[2] Part of the reason for more efficient shooting skill has been the development of the jump shot. Because of the versatility of the jump shot, it has become the most important offensive weapon in the game of basketball.[3] Benington and Newell's point is supported by Sharmin who said, "The jump shot is the most effective and potent shot in basketball today."[4] Wooden also

---

[1]Bill Sharmin, Sharmin on Basketball Shooting (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1965), p. 21.

[2]John Benington and Pete Newell, Basketball Methods (New York: The Ronald Press Company, 1962), p. 124.

[3]Ibid.

[4]Sharmin, op. cit., p. 53.

supported this viewpoint as he stated that his teams score more points from jump shots than all of the other types of shots combined.[5]

With the jump shots established as the popular method of shooting, it would be of value to coaches to be able to predict success in scoring from the field by utilizing the jump shot. Since accurate shooting depends upon certain physical qualities, it was valuable for the investigator to study the relationship of selected anatomical measurements and motor responses to jump shooting ability in basketball.

Statement of the Problem

The purpose of this investigation was to study the relationship between jump shooting ability in basketball and the qualities of hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, wrist strength, and agility.

Hypotheses

1. There is no relationship between jump shooting ability in basketball and selected anatomical measurements and motor responses.

2. A multiple regression equation to significantly predict jump shooting ability in basketball cannot be developed.

---

[5]John Wooden, Practical Modern Basketball (New York: The Ronald Press Company, 1966), p. 95.

Limitations and Delimitations

1. Twenty-four male athletes from the South Dakota State University varsity and junior varsity basketball teams were used as subjects.

2. Only jump shooting ability in basketball was investigated.

3. The shots were taken at distances of 10 and 21 feet along the angles of 0 degrees left, 45 degrees left, 90 degrees, 45 degrees right, and 0 degrees right.

4. The variables investigated were hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, wrist strength, and agility.

5. All shots were taken during practice in an unguarded situation.

6. No attempt was made to control psychological factors which may have affected performance.

Definition of Terms

Agility. The physical ability enabling an individual to change bodily position and direction in a precise and rapid manner.[6]

---

[6] Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis: The Burgess Publishing Company, 1970), p. 100.

Depth perception. The ability to perceive the distance to an object in one's environment through learned associations and the coordinated use of two eyes.[7]

Flexibility. The normal range of movement of an anatomical segment about its joints.[8]

Hand size. For the purpose of this study, hand size refers to the sum of the length and width of the shooting hand.

Kinesthetic perception. The ability to perceive the position and movement of the body and its joints during muscular action, also known as muscle sense.[9]

Leg power. Leg power is the ability of the legs to provide the inertia to propel the body through space.[10]

Peripheral vision. The ability which enables an individual to be somewhat aware of his surroundings without constantly turning his head.[11]

Reaction time. The interval in time between the reception of a stimulus and the initiation of the response.

---

[7]Kenneth N. Ogle, Researches in Binocular Vision (New York: Hafner Publishing Company, 1964), pp. 133-135.

[8]Jack Leighton, "A Simple, Objective and Reliable Measure of Flexibility," Research Quarterly, 31:205-216, May, 1942.

[9]Johnson and Nelson, op. cit., p. 182

[10]Ibid.

[11]Frederick D. Cornett, Thomas F. Morrison and J. Edward Tether, Human Physiology (New York: Henry Holt and Company, 1959), p. 126.

Speed of movement. Rate at which a person can propel his body or parts of his body through space.[12] For the purpose of this study, the concern was with the shooting arm and hand.

Strength. The force a muscle group can exert against a resistance in one maximal effort.[13]

---

[12]Johnson and Nelson, op. cit., p. 227.

[13]Edward L. Fox and Donald K. Mathews, The Physiological Basis of Physical Education and Athletics (Philadelphia: W. B. Saunders Company, 1971), p. 68.

CHAPTER II

REVIEW OF THE LITERATURE

Many studies have been conducted in the area of basketball shooting ability and in the area of general motor ability in specific athletic events. The purpose of this chapter was to survey the findings of studies concerned with the variables being considered in this investigation as they relate to basketball shooting ability. The literature was divided into the categories of: Hand-eye coordination, hand reaction and speed of movement time, grip and wrist strength and hand size, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, and agility.

Literature Related to Eye-Hand Coordination

As early as 1939, McCloy felt that eye-hand coordination was an important factor in motor educability and should be included in a motor educability testing program.[1] The following year, he included eye-hand coordination as part of a list of sixteen components of motor educability. McCloy then recommended that tests be used which would measure each of these components separately, taking into account the age of the subject.[2]

---

[1] C. H. McCloy, _Tests and Measurements in Health and Physical Education_ (New York: Harper and Row, 1963), p. 146.

[2] C. H. McCloy, "A Preliminary Study of Factors in Motor Educability," _Research Quarterly_, 11:28-39, May, 1940.

Davis and Lawther felt that a great deal of automatic habit performance seemed to be involved in highly skilled motor performances.[3] The performer moves his hands into position while focusing on the rapidly approaching ball. He dribbles the basketball and changes rate of speed or direction while centering his attention on teammates down the floor, estimating their speed and distance from their opponents.[4]

According to Willberg, eye-hand coordination can be divided into two different phases: (1) The initial location of the stimulus, and (2) motor reaction in response to the situation. He attempted to find the relation of the initial visual stimulus location and the motor response when the number of possible choices in the visual field was increased.[5] Willberg found that the subject made one of two types of errors: (1) locating the stimulus object incorrectly, and (2) incorrect motor response, which was usually due to loss of perceptual information, or incorrect use of the information. Errors of incorrect motor response occured more often than errors in locating the stimulus object.[6]

Ross devised four tests involving handling of objects to study eye-hand coordination. These tests were ring toss, ball bounce below waist, wall-rebound-catch above waist, and a bean bag target throw. Ross

---

[3] Elwood C. Davis and John Lawther, Successful Teaching in Physical Education (New York: Prentice Hall, Inc., 1948), p. 338.

[4] Ibid.

[5] Robert B. Willberg, "Hand-Eye Coordination Determined by the Variability in Visual and Motor Responses," (Unpublished Master's thesis, University of Oregon, Eugene, 1960), p. 3.

[6] Ibid., p. 33.

attempted to determine if there was a relationship between these measures of eye-hand coordination and visual perception. His visual tests included depth perception, eye usage (right, left and both), and size constancy. Twenty-four subjects from grades two, four and six were used in his study. A pilot study using the odd-even method gave high reliability scores. From this study Ross concluded that depth perception was not significantly related to any of the motor tests, but the positive correlations indicated that a child's performance of a motor skill was, in part, dependent on visual skills.[7] Ross went on to state that, "Seeing is not determined by vision alone."[8]

Barrow, in devising his test of motor ability, including the wall pass test along with some of the tests used by McCloy and Cozens. He obtained a reliability coefficient of .791 and an objectivity coefficient of .950. A correlation coefficient of .761 with the criterion (general motor ability) was found using the wall-pass test as a measure of eye-hand coordination in his motor ability test.[9]

In 1957 Stroup devised a battery of tests to measure basketball ability and related these to field of motion perception. Test items included were: diagonal wall pass, jump and reach, shooting test (one minute), wall pass (one minute), and dribbling test. He selected these

---

[7]Mattie E. Ross, "The Relationship of Eye-Hand Coordination Skills and Visual Perception Skills in Children" (unpublished Doctoral dissertation, Ohio State University, Columbus, 1961), pp. 1-102.

[8]Ibid.

[9]Harold M. Barrow, "Test of Motor Ability for College Men," Research Quarterly, 25:253-260, October, 1954.

items because of their reliability, validity, and ease of administration. One hundred twenty college men in team sports were selected as subjects. The results showed a significant difference (.01 level) between varsity basketball aspirants and players who had never made a basketball team. Also, the wall pass showed the highest correlation of the five variables when correlated with the criterion (motion perception test). Stroup's test showed a forecasting efficiency of 41.8 when used for predictive purposes.[10]

The Johnson basketball ability test includes a wall pass test for accuracy and speed.[11] Lehsten used a wall pass test as one of the four items in his ability test.[12] A relatively high predictability index was reported by Knox using an ability test which included: wall pass, speed dribble, dribble-shoot, and penny-cup tests, all against time. His subjects were players from eight area Class B basketball teams. The criterion for this test was based upon the number of points they scored in league play. Knox found that he could predict nine of ten team members using this test and also the dribble-shoot test proved to be the best for predictive purposes.[13]

---

[10]Francis Stroup, "Relationship Between Measurements of Field of Motion Perception and Basketball Ability in College Men," Research Quarterly, 28:72-75, March, 1957.

[11]William L. Johnson, "Objective Test in Basketball for High School Boys," The Physical Educator, 5:103-109, December, 1948.

[12]Nelson Lehston, "A Measure of Basketball Skills for High School Boys," The Physical Educator, 5:103-109, December, 1948.

[13]Robert D. Knox, "Basketball Ability Tests," Scholastic Coach, 17:45-47, November, 1947.

Literature Related to Reaction Time and Speed of Movement

In one of the early studies on speed of movement, Hill concluded that the viscosity of the muscular fluid was a factor in limiting speed of movement.[14] This point was supported by Rarick in 1937 when he stated that the chief factor limiting speed of movement is the viscosity of man. Another conclusion of his study was that fat, which he calls "dead weight," acts to hinder speed of muscular movement. Rarick's results seemed to indicate that normal individuals with a high degree of motor ability or skill and an average amount of strength cannot appreciably increase their speed of movement.[15]

In 1931 Westerlund and Tuttle studied the relationship of reaction time in track running events using a finger response testing device. They found a high degree of relationship (r=.863) between speed in running seventy-five yards and reaction time.[16] In another study completed the following year by Lautenback and Tuttle, a similar conclusion was reached. This study showed a correlation coefficient of .815 between speed in sprinting and reflex time. Reflex time was found to be significantly related to reaction time.[17]

---

[14]A. V. Hill, Muscular Movement in Man (New York: McGraw-Hill Book Company, Inc., 1927), p. 32.

[15]Lawrence Rarick, "An Analysis of the Speed Factor in Simple Athletic Activities," Research Quarterly, 8:89-105, December, 1937.

[16]J. H. Westerlund and W. W. Tuttle, "Relationship Between Running Events and Reaction Time," Research Quarterly, 2:95-100, October, 1931.

[17]Ruth Lautenback and W. W. Tuttle, "The Relationship Between Reflex Time and Running Events in Track," Research Quarterly, 3:138-143, October, 1932.

The importance of reaction time in skills was emphasized by Burpee and Stroll when they stated:

> Although several splendid attempts have been made to isolate the factors involved in attaining success in physical education activities, few, if any, have attempted to measure the importance of reaction time. This is largely because suitable apparatus has not usually been available.[18]

Beise and Peasley, in 1937, studied arm and foot reaction time of 47 skilled women in golf, tennis, and archery, and compared them to 14 unskilled women (far below average). The results showed that the skilled group had a significantly better reaction time and speed of movement time.[19]

A study completed by Burley showed a significantly faster reaction time among baseball and basketball players than among football linemen and backs.[20] Keller found that the reaction time of athletes in baseball, basketball, football and track was significantly better than those in gymnastics, wrestling and swimming. It was also found that a positive relationship existed between success in athletic skills and the ability to move the body quickly.[21] Patrick supported these findings when

---

[18] R. H. Burpee and W. Stroll, "Measuring Reaction Time of Athletes," Research Quarterly, 7:110-118, March, 1936.

[19] Dorothy Beise and Virginia Peasley, "The Relationship of Reaction Time, Speed and Agility of Big Muscle Groups to Certain Sports Skills," Research Quarterly, 8:133-142, March, 1937.

[20] Lloyd R. Burley, "A Study of the Reaction Time of Physically Trained Men," Research Quarterly, 15:232-235, October, 1944.

[21] L. B. Keller, "The Reaction of Quickness of Bodily Movement to Success in Athletics," Research Quarterly, 13:146-155, March, 1942.

he said, "Quick reaction time is considered to be an earmark of a good athlete."[22] Erickson observed that, "The relationship between reaction time and success in athletics is a point of controversy and is not definite, although some studies indicated a positive relationship between the two."[23]

Clarke and Glines, in a study on 13-year old boys in 1962, found little relationship between the reaction times of various parts of the body. They also concluded that reaction time is independent of other strength or anthropometrical measurements and should be considered as a specific trait.[24]

A study to determine the difference between reaction time and speed of movement in males and females was conducted by Hodgkins. She studied 930 men, women, and children from age six to eighty-four to determine differences between males and females in reaction time and speed of movement time, and to ascertain if a relationship exists between the two. The results showed: (1) Males were faster than females in both areas, (2) No relationship was found between reaction time and speed of movement time, (3) Both males and females increased in reaction time and

---

[22]J. Patrick, "Quick Reaction Time Means Athletic Ability," Athletic Journal, 10:30-68, September, 1949.

[23]C. E. Erickson, "A Study to Determine the Relationships Between Certain Psychological Capacities and Success in Coaching Football" (unpublished Doctoral dissertation, Boston University, Boston, 1953), pp. 44-45.

[24]H. Harrison Clarke and Donald Glines, "Relationships of Reaction, Movement and Completion Times to Motor Strength, Anthropometric and Maturity Measures in 13-year old Boys," Research Quarterly, 32:194-200, May, 1962.

speed of movement time until early adulthood and then decreased, and (4) Males maintained peak speed of movement for a longer time, while females maintained peak speed in reaction time for a longer time.[25]

Recent studies done on reaction time have been beneficial in the development of tests. Smith, in 1964, found reaction time and speed of movement time to be greater when the muscle was partially contracted than when it was completely relaxed.[26] A study done in 1969 found no effect of fatigue on reaction time.[27]

In 1953, Patty conducted a study to determine the relationship of certain physical, mental, perceptual, and sensory characteristics to successful performance in basketball. The subjects were 271 male students at Indiana State University. Of these, 101 were candidates for basketball teams and the other 170 were chosen from basic skills classes in basketball. He found that successful basketball players were significantly better than unsuccessful basketball players in reaction time. Reaction time was measured by a light response system consisting of a pad attached to the wall which the player struck when he saw the light begin to glow.[28]

---

[25]Jean Hodgkins, "Reaction Time and Speed of Movement in Males and Females of Various Ages," Research Quarterly, 34:335-343, October, 1963.

[26]Leon E. Smith, "Effect of Muscular Strength, Tension, and Relaxation Upon the Reaction Time and Speed of Movement of a Supported Limb," Research Quarterly, 35:546-553, December, 1964.

[27]Carlton R. Meyers, William Zimmerli, S. David Farr, and Norbert A. Baschnagel, "Effect of Strenuous Physical Activity Upon Reaction Time," Research Quarterly, 40:332-337, May, 1969.

[28]Elbert K. Patty, "The Relationship of Selected Measurable Traits to Success in Basketball" (unpublished Doctoral dissertation, Indiana University, Bloomington, June, 1953), pp. 1-130.

Patty went on to state, "These findings were not surprising since the game of basketball would appear to require quick movements, the ability to keep one's balance after jumping or leaping, and the quick initiation and repetition of positions and movements."[29]

The Nelson Reaction Timer was used by Johnson and Nelson in tests of reaction time and speed of movement. They found reliability coefficients of .89 when measuring reaction time and .75 when measuring speed of movement time in college men. Face validity was accepted as long as no attempt was made to separate reaction time and speed of movement.[30]

Literature Related to Grip and Wrist Strength and Hand Size

A leader in the field of strength testing, according to Mathews, was D. A. Sargent, who devised a test known as the Intercollegiate Strength Test in 1873. His test included back and leg strength as measured by a dynamometer, grip strength as measured by a manuometer, lung capacity as measured by the wet spirometer, and arm strength as measured by dips and pull-ups.[31]

Mathews also reported on strength studies involving resistance to pull which were introduced by Martin in 1915. This "break technique" as it was later called, used a spring scale for measuring eleven muscle

---

[29]Ibid.

[30]Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis: The Burgess Company, 1970), pp. 28-36.

[31]Donald K. Mathews, Measurements in Physical Education (Philadelphia: W. B. Saunders Company, 1963), pp. 68-70.

groups. The test was eventually shortened to one test of the muscles of the forearm and correlated .91 with the original test.[32]

Several studies have been done comparing left hand and right hand grip strength. Bookwalter found more variation in left hand grip strength than in right hand grip strength. His results showed right hand grip strength to be consistently greater than left in relation to age and weight.[33] Laiding, Monpetit, and Montoye stated that left-handed people are more likely to have a dominant right hand, but the opposite is true for right-handed people. They attributed this to the influence of a right-handed society.[34]

In a study relating grip strength to body measurements, Everett and Sills found the width of the hand to be more highly related to grip strength than was the length of the hand or fingers.[35] Scott stated that hand and arm size can be misleading when judging grip strength.[36] In a related study done in 1962, O'Connell and Pierson found grip strength was

---

[32]Ibid.

[33]Karl W. Bookwalter, "Grip Strength Norms for Males," Research Quarterly, 21:249-253, October, 1950.

[34]Lawrence Laiding, Richard Monpetit, and Henry J. Monteye, "Grip Strength of School Children, Saginaw, Michigan: 1889 and 1962," Research Quarterly, 38:231-237, May, 1967.

[35]Peter Everett and Frank Sills, "The Relationship of Grip Strength to Stature, Somatotype Components, and Anthropometric Measurements of the Hand," Research Quarterly, 42:241-246, May, 1952.

[36]M. Glady Scott, Analysis of Human Motion (New York: Appleton-Century-Crofts, 1963), p. 244.

significantly related to weight, but not to age or height.[37] Bowers found a significant relationship between hand and arm size and grip strength.[38]

Cratty stated that reaction time, arm speed and grip strength are independent and exhibit little relationship, but "There is a high correlation between grip strength and persistence in performance of a task."[39]

O'Connell and Pierson, when comparing grip strength of gymnasts, football players, and basketball players, found no significant difference among these groups.[40]

Arm strength was found to correlate the highest with a basketball achievement test in a study conducted by Hinton and Rarick using 64 college girls as subjects. The criterion was a composite score obtained on the Cubberley and Cozens Basketball Achievement test. Although arm strength correlated the highest with the criterion, it showed a low intercorrelation with the other strength tests (grip, back and legs). Hinton and Rarick concluded that "Arm strength and other strength tests do not measure the same thing."[41] They went on to state that "The other

---

[37]Eugene R. O'Connell and William R. Pierson, "Age, Weight, and Grip Strength," Research Quarterly, 32:439-443, October, 1962.

[38]Louis E. Bowers, "Investigation of the Relationship of Hand Size and Lower Arm Girths to Hand Grip Strength as Measured by Selected Hand Dynamometers," Research Quarterly, 32:308-314, 1961.

[39]Bryant J. Cratty, Movement Behavior and Motor Learning (Philadelphia: Lea and Febiger, 1967), p. 225.

[40]O'Connell and Pierson, loc. cit.

[41]Evelyn A. Hinton and Lawrence Rarick, "The Correlation of Roger's Test of Physical Capacity and the Cubberley and Cozens Measurement of Achievement in Basketball," Research Quarterly, 11:58-65, October, 1940.

strength tests combine with arm strength to predict the basketball test to a fairly high degree."[42] Also, it was felt that although arm strength may be important, the development of arm strength usually leads to the development of general body strength. In conclusion they stated, "This finding would lead one to believe that strength of the arms plays a greater part in the acquiring of basketball skills than would ordinarily be thought."[43]

Di Giovanna found that basketball players exhibited much greater explosive power, arm pull, and leg strength than the other groups of athletes in his study. In summarizing his conclusions, Di Giovanna stated, "These factors are associated with athletic success."[44]

Sharmin, in discussing jump shooting, stated, "I emphasize a very strong wrist snap, including a complete follow-through."[45] He went on to say, "The over-the-head jump shot leverage is controlled mainly by wrist snap."[46] Cousy supported Sharmin's views when he stated, "In shooting a jump shot, much of the energy is converted to altitude; the remaining force required to reach the basket must come from the arms,

---

[42]Ibid.

[43]Ibid.

[44]Vincent Di Giovanna, "The Relation of Selected Structural and Functional Measures to Success in College Athletics," Research Quarterly, 14:199-215, May, 1943.

[45]Bill Sharmin, Sharmin on Basketball Shooting (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), p. 40.

[46]Ibid., p. 60.

wrists and fingers."[47] Sharmin reiterated the importance of the fingers when he said, "When gripping the ball, only the fingers should come in contact with the ball."[48]

While attempting to determine what traits were possessed by successful basketball players, Patty found that successful players had significantly better scores than unsuccessful players in grip strength, hand width and length, and arm pull. Grip strength was measured by using a manuometer and arm pull was measured with a dynamometer. Hand width was determined by measuring the hand imprint across the base of the fingers (width) and from the tip of the index finger to the heel of the hand on the radius side (length). Of the 24 traits measured by Patty, 17 were found to be significant when comparing the successful players (team candidates) to unsuccessful players (basic skills class).[49]

Commenting on testing grip strength, Hunsicker and Greey stated that body position is an important factor in measuring strength. They felt the best position was standing with a good base, knees slightly bent, and the arm to be measured held at an elbow flexion angle of 90 degrees.[50]

Several reliable instruments have been devised to measure grip strength. Bowers, in studying the reliability of three different

---

[47]Bob Cousy, Basketball Concepts and Techniques (Boston: Allyn and Bacon, Inc., 1970), p. 39.

[48]Sharmin, op. cit., p. 33.

[49]Patty, loc. cit.

[50]George Greey and Rod Hunsicker, "Studies in Human Strength," Research Quarterly, 28:111-118, May, 1959.

instruments, found a significant difference in mean scores between the cable tensiometer and the Narragansett hand dynamometer. His results indicated that adjusting the dynamometer improved the possibility of obtaining grip strength scores relative to hand size and length. He found reliability coefficients of .95 for the cable tensiometer, .91 for the Smedley adjustable dynamometer, and .89 for the Narraganset hand spring dynamometer.[51]

Alderman and Banfield considered the cable tensiometer to be best for measuring grip strength because it had the advantages of (1) Manipulation of body and joint angle to an effective position for maximum application of strength, and (2) Objective recordings on the dial. For the eight tests conducted, they found reliability coefficients ranging from .74 to .98. The results of their tests showed: (1) No significant difference in reliability between random administration and standard administration, and (2) The use of the best score over the mean score did not affect reliability.[52]

Cotten and Johnson conducted a study to determine if varying the span setting of the adjustable grip attachment of the T-5 tensiometer affected the grip strength reading of college men, and if so, how the best setting could be determined. Their results showed that a setting

---

[51]Bowers, loc. cit.

[52]Richard B. Alderman and Terry Banfield, "Reliability Estimation in the Measurement of Strength," Research Quarterly, 40:448-454, October, 1969.

of medium small (MS = 5.25 cm.) was the best setting for testing grip strength in males.[53] In a similar test conducted by Cotten and Bonnell on college women, the medium small setting was also found to be the best setting. Results of this study showed significantly different strength measures with a change in setting, and significantly higher readings were obtained with the MS setting.[54]

In a test-retest situation using the cable tensiometer, Knoll found that the reliability score increased from .91 to .99 indicating a high retest reliability.[55]

Regarding the number of trials, Bowers considered the mean of four trials as the measure of grip strength for the subject.[56] Monpetit, Montoye, and Laiding stated that one trial, as compared to two trials, decreased the mean for grip strength about one kilogram. They felt that in a research study this might cause a significant difference.[57]

Literature Related to Peripheral Vision

Barclay conducted a study to determine the relationship existing between vision and certain athletic skills. His results did not show a

---

[53]Doyice J. Cotten and Allen Johnson, "Use of the T-5 Cable Tensiometer Grip Attachment for Measuring Strength of College Men," Research Quarterly, 41:454-56, October, 1970.

[54]Doyice J. Cotten and Lorraine Bonnell, "Investigation of the T-5 Cable Tensiometer Grip Attachment for Measuring Strength of College Women," Research Quarterly, 40:848-50, December, 1969.

[55]Walter Kroll, "Reliability Variations of Strength in Test-Retest Situations," Research Quarterly, 34:50-55, March, 1963.

[56]Bowers, loc. cit.

[57]Laiding, Monpetit, and Montoye, loc. cit.

significant relationship between eye-efficiency scores and basketball shooting success. Therefore, Barclay felt that the statement, "he has a good eye" could not be supported by statistics.[58]

A study done by Hobson and Henderson on the relationship between success in basketball and visual field size revealed that the best pass concealer (rating by coaches) had a horizontal visual field fifteen degrees larger than other players.[59]

Frank Low, in 1946, developed an apparatus for measuring peripheral vision. The apparatus, consisting of a flat half circle with a radius of eighteen inches, was placed on the horizontal eye-level of the subject. Each eye was tested separately. The subject fixed his eye on an object on the edge of the platform directly ahead of him. A Landolt Ring, which is a circle with a minute break on its edge, was illuminated by an instrument much like a flashlight. The position and size of the break was changed, as was the position of the ring within the peripheral field of the platform. The Ring was illuminated for .5 seconds. The subject's ability to accurately locate the position of the break at the various angles was considered to be an indicator of his peripheral visual acuteness.[60]

---

[58] George D. Barclay, "The Relationship Between Efficient Vision and Certain Sensory Motor Skills" (unpublished Doctoral dissertation, New York University, New York City, 1938), pp. 1-87.

[59] Robert Hobson and M. T. Henderson, "A Preliminary Study of the Visual Field in Athletics," Iowa Academy of Sciences, 48:331-340, 1941.

[60] Frank N. Low, "Some Characteristics of Peripheral Vision Performance," American Journal of Physiology, 146:573-584, July, 1946.

Sherman developed a new program for training in drawing. His program involved having students sit in a darkened room and reproduce pictures that were flashed upon a movie screen for 1/10 second. They were then given one and one half minutes to reproduce the image. On the five tests of visual acuity, the experimental group gained more than the control group. The experimental group showed significant gains in central acuity, peripheral acuity, and peripheral stereo-acuity. Sherman found the significant gain in central acuity to be of particular interest because the literature seems to indicate that training can do little to improve central acuity.[61] The implication of this study to athletics and physical education was pointed out by Sherman when he stated:

> Most sports--notably football, basketball, baseball, hockey, soccer, tennis, and handball--require a high degree of visual skill if competency is to be achieved in the sport. The good player must be able to see the whole visual field in which the play is emerging, and he must see most of it as peripheral vision, out of the corner of his eye.[62]

The training in drawing increased the field of peripheral vision of students in this demonstration by 86 percent and increased the accuracy of depth judgments in the periphery by 400 percent.[63] In another study Sherman further supported this view by observing that "peripheral vision is more important than central vision."[64] He felt that central vision

---

[61] Hoyt Sherman, Drawing by Seeing (New York: Hinds, Hayden and Eldridge, 1947), pp. 1-77.

[62] Ibid., p. 56.

[63] Ibid.

[64] Hoyt Sherman, "Aspects of Visual Perception and Their Relationships to Motor Activity," 53rd Annual Proceedings, College Physical Education Association (Washington, D. C. College of Physical Education Association, 1959), p. 8.

was more concerned with identification and analysis while peripheral vision was more concerned with position and mass.[65]

A study by Stroup concluded that peripheral vision contributed greatly to basketball ability. In his study, Stroup compared basketball players and nonbasketball players in their field of motion perception. A real, but not significant, difference between the range of perception in the two groups was found. Also obtained was a correlation of .765 between measurements of peripheral vision and basketball ability.[66] In conclusion, he stated, "This was interpreted as indicating a real relationship between the range of motion perception and basketball ability."[67]

Banister and Blackburn found that better ball players have larger interpupillary distances and from that they concluded that the players would also have better peripheral vision.[68]

When judging the distance to the basket, Cousy felt that the player's eyes computed the distance by comparing texture, converging lines, or other visual stimuli with previous experience. He felt that these factors in the field of vision aided in improving the shooting accuracy of a basketball player.[69]

---

[65] Ibid.

[66] Stroup, loc. cit.

[67] Ibid.

[68] H. Banister and J. M. Blackburn, "An Eye Factor Affecting Proficiency in Ball Games," British Journal of Psychology, 21:382-384, 1930.

[69] Cousy, op. cit., p. 38.

Gallager concluded that a keen natural vision is not as important in motor learning as it was once thought to be.[70]

Cobb conducted a study on color recognition in the field of vision and found that some colors, notably red and blue, are more easily perceived in the field of vision. Cobb stated that testing peripheral vision is highly subjective since the tester must depend upon the subject's description of what he perceives. He feels that there is a definite lack of testing equipment in this area. New testing methods and equipment are all basically the same.[71]

Literature Related to Depth Perception

A study by Dickson investigated the relationship of depth perception to shooting ability in basketball. In his study Dickson stated, "The perception of distance is probably the most important factor in the success of basketball shooting."[72] The results of his study did not show a significant relationship between shooting ability and depth perception. Dickson felt that "The tests of depth perception do not measure the factors of depth perception requisite to basket-shooting ability."[73]

Winograd investigated binocular visual efficiency and depth perception in varsity and rejected baseball players and non-athletes. His

---

[70]James Gallager, "A Study of Changes in Eye Movement and Visual Focus During the Learning of Juggling" (unpublished Master's thesis, Pennsylvania State University, University Park, 1961), p. 16.

[71]Robert A. Cobb, "A Comparative Study of Color Recognition in the Peripheral Field of Vision of Participants in Selected Sports" (unpublished Master's thesis, Springfield College, Springfield, 1967), pp. 52-53.

[72]Joseph F. Dickson, "The Relationship of Depth Perception to Goal Shooting in Basketball" (unpublished Doctoral dissertation, State University of Iowa, Iowa City, 1934), pp. 11-12.

[73]Ibid.

study revealed superior vision in athletes when compared to non-athletes, and a reliable difference in visual scores of varsity players when compared to non-athletes and rejected athletes.[74]

Clark and Warren compared athletes to non-athletes to determine if success in sports was related to either depth perception or interpupillary distance. They used a modification of the Howard-Dolman apparatus to measure depth perception and another gauge to measure interpupillary distance. Their results showed: (1) No significant relationship between depth perception and interpupillary distance and (2) No significant difference between athletes and non-athletes in interpupillary distance or depth perception.[75]

McCloy and Young listed depth perception as one of the probable essentials in motor educability. They continued by saying:

> It is highly probable that in many athletic sports, depth perception is a factor of importance. The ability to field a fly ball, to intercept a hard driven ball in baseball, to intercept and catch a long pass in basketball, to shoot goals, and to execute many other performances would seem to be related to depth perception.[76]

Olsen used the Howard Dolman apparatus to study depth perception in intermediate athletes and non-athletes. In his review of the literature, Olsen concluded that there was little if any relationship between depth

---

[74] Samuel Winograd, "Relationship of Timing and Vision to Baseball Performance," Research Quarterly, 13:481-493, December, 1942.

[75] Brant Clark and Neil Warren, "Depth Perception and Interpupillary Distance as Factors in Proficiency in Ball Games," American Journal of Psychology, 47:485-487, July, 1935.

[76] Charles H. McCloy and Norma D. Young, Tests and Measurements in Health and Physical Education (New York: Appleton-Century-Crofts, Inc., 1954), p. 497.

perception and motor performance.[77] The results of this study showed a significant difference between athletes and intermediate athletes in depth perception and apprehension span and much better (not significant) depth perception in athletes and intermediate athletes than in non-athletes.[78]

Mail reported that depth testing has been used extensively since 1919 by military and automotive personnel to examine pilots and drivers. She felt that the Howard-Dolman apparatus enabled practical testing in this area of perception.[79] Mail felt that a wide variety of gross motor skills depend upon the analysis of, and reaction to, visual cues.[80]

Literature Related to Kinesthetic Perception

In 1936 Honzik conducted a study of rats to determine what role kinesthesis played in maze learning. His results showed that kinesthesis may not be relatively important to maze learning, but seems to be essential to the smooth flow of movements after learning has begun due to other stimuli. Honzik concluded that kinesthesis is not necessary to learning or perfecting a habit, and learning by kinesthesis alone is impossible.[81]

---

[77] Einar A. Olsen, "Relationship Between Psychological Capacities and Success in College Athletics," Research Quarterly, 27:78-79, March, 1956.

[78] Ibid.

[79] Patricia D. Mail, "The Influence of Binocular Depth Perception in the Learning of a Motor Skill" (unpublished Master's thesis, Smith College, Northampton, Massachusetts, 1965), p. 10.

[80] Ibid., p. 14

[81] C. H. Honzik, "Role of Kinesthesis in Maze Learning," Science, 22:873-874, 1936.

According to Phillips, "Efficient kinesthesis is essential to defined motor performance."[82] To support this statement, Phillips used a group of college men to study the relationship between ten kinesthetic tests and the skills of playing a ten foot putt and playing a golf ball for accuracy at a target eighteen feet from the tee. He found a low positive relationship between certain phases of kinesthesis and performance success in the early stages of skill acquisition. Other phases showed a zero or negative relationship.[83]

Arm raise and balance stick, target pointing, and Young's battery of kinesthetic tests were recommended by Fisher on the basis of the results of her study on high school girls. She found small positive correlations between the kinesthetic tests used and general motor ability and capacity. Her results were too low to be used for prediction.[84]

Young administered 19 kinesthetic tests to a group of college women. Through the use of multiple correlations she recommended arm raising, leg raising, and balance stick as a battery of tests for additional study in kinesthesis. When these three tests were correlated to a score of all 19 tests, a multiple correlation of .984 was obtained.[85]

Roloff viewed kinesthesis not as a single sense but as a composite, with a number of sense organs as contributors. Various proprioceptors help

---

[82] B. E. Phillips, "Kinesthesis and Its Relation to Learning Motor Skills," Research Quarterly, 12:571-577, October, 1941.

[83] Ibid.

[84] Rosemary Fisher, "A Study of Kinesthesis in Selected Motor Movements" (unpublished Master's thesis, State University of Iowa, Ames, 1945), p. 31.

[85] Olive G. Young, "A Study of Kinesthesis in Relation to Selected Movements," Research Quarterly, 16:227-237, 1945.

to acquaint an individual with the position of his arms and legs in relation to the rest of his body.[86] The importance of the proprioceptors was pointed out by Roloff when she stated, "Without such information which is relayed to the central nervous system, there could be no coordinated and adjusted movements."[87] She viewed kinesthetic sense as one of the contributing factors in the individual's ability to learn an activity or skill.[88]

A study comparing the effectiveness of teaching the one-hand push shot by three different methods was undertaken by Halverson in 1949. The three methods used were: mental practice, overt practice, and kinesthetic awareness. The latter placed emphasis on kinesthetic memory of the shot and suggested recall of range of motions, the amount of force, the feeling of quick extension, and feel of balance on the lead foot after release.[89]

The importance of kinesthesis was emphasized by Oberteuffer when he stated, "The individual with a keen kinesthetic sense can 'feel' each shot or stroke and 'sense' the smoothness and accuracy of the muscular efforts."[90] Added support for this idea was given by Phillips when he

---

[86]Louise L. Roloff, "Kinesthesis in Relation to the Learning of Selected Motor Skills" (unpublished Doctor of Philosophy dissertation, Iowa State University, Ames, 1952), p. 19.

[87]Ibid.

[88]Louise L. Roloff, "Kinesthesis in Relation to Motor Learning," Research Quarterly, 24:210-213, May, 1953.

[89]Lolas Halverson, "A Comparison of Three Methods of Teaching Motor Skills" (unpublished Master's thesis, University of Wisconsin, Madison, 1949), pp. 1-83.

[90]Delbert Oberteuffer, Physical Education (New York: Harper and Brothers, 1951), pp. 1-374.

indicated that both psychologists and coaches seem to agree that kinesthesis is necessary for superior motor performance.[91]

In a study conducted on college women basketball players, Zimmerman found the highly skilled player tended to have a slightly better kinesthetic sense than the less skilled performer.[92] She used several different measures of kinesthesis with arm raise and balance stick giving the highest correlations with the criterion.[93]

Literature Related to Leg Power

Among the research done to determine the best test of leg power was a study done in 1962 by Gray, Start, and Glencross. In this study, the jump reach test, standing broad jump, squat jump, and the modified vertical power jump were compared with a criterion measure (vertical power jump). The modified vertical power jump was determined to be the best test of leg power because it showed a reliability measure of .977 and validity of .989 when correlated with the criterion.[94]

---

[91]Bernath Phillips, "The Relationship Between Certain Phases of Kinesthesis and Performance During the Early Stages of Acquiring Two Perceptuo-Motor Skills" (unpublished Master's thesis, Pennsylvania State College, Philadelphia, 1941), pp. 1-77.

[92]Patricia Ann Zimmerman, "The Relationship of Kinesthesis to High and Low Levels of Basketball Ability Among College Women" (unpublished Master's thesis, University of Illinois, Urbana, 1961), pp. 1-68.

[93]Ibid.

[94]R. K. Gray, K. B. Start, and D. J. Glencross, "A Useful Modification of the Vertical Power Jump," Research Quarterly, 32:230-234, May, 1962.

The vertical power jump, or Sargent jump test, was originated by D. A. Sargent in 1921 and later validated by L. W. Sargent.[95] Henry reported that evidence of its validity was also found by Collins and Howe, Bovard and Cozens, and McCloy.[96]

McCloy stated that the Sargent jump test was the best single test for predicting leg power.[97] He went on to say:

> Since speed and vigor of movement are characteristics of many of the athletic sports such as football, baseball, and basketball, it would follow that the Sargent Jump should be an excellent item to be included in a battery of tests designed to test, among other things, this item of explosive muscular contractions.[98]

In establishing the validity of the Sargent Jump, L. W. Sargent studied the jump as it is related to the body build and age in men and women. Some of his observations were: (1) For men and women above high school age, the jump is unrelated to height and weight, (2) There is a high correlation between athletic ability and skill in the jump, and (3) Strength, speed, coordination, and will power are not necessary factors in the performance of the jump.[99] The results of Sargent's study showed: (1) No significant relationships between the Sargent Jump and body build (leg strength, height, weight, or any other anthropometrical

---

[95] L. W. Sargent, "Some Observations of the Sargent Test of Neuro-muscular Efficiency," American Physical Education Review, 29:47, February, 1924.

[96] Franklin Henry, "The Practice and Fatigue Effects in the Sargent Jump," Research Quarterly, 13:16-29, March, 1942.

[97] C. H. McCloy, "Recent Studies in the Sargent Jump," Research Quarterly, 2:235-242, May, 1932.

[98] Ibid.

[99] L. W. Sargent, loc. cit.

measurement), and (2) No significant relationship between the height of the jump and the amount of squat preceding the jump.[100]

Van Dalen, in a study correlating the Sargent Jump to track and field events, pointed out that a maximum contraction in a minimum amount of time is required in track and field events. These events are considered to be power events and include running, throwing, and jumping. He further added that there may be a high relationship between the Sargent Jump and basketball ability since basketball consists chiefly of running, jumping and throwing.[101]

In a similar study, McCloy found a reliability coefficient of .890 when correlating four track and field events, considered to be power events, and the Sargent Jump. He also found higher correlations when the best result of more than one day's jump was used.[102]

Henry found that the reliability of the Sargent Jump was influenced by fatigue and practice, but fatigue during the experiment did not affect the validity.[103]

Martin and Stull conducted a study to determine the best knee angle and foot spacings for performing the vertical jump. Their results showed that knee angle, lateral foot spacings, and anterio-posterior foot spacings exert independent effects on vertical jumping performance. They

---

[100]Ibid.

[101]Deobald Van Dalen, "New Studies in the Sargent Jump," Research Quarterly, 11:113-116, May, 1940.

[102]McCloy, loc. cit.

[103]Henry, op. cit., p. 29.

concluded that the most effective stance was with a knee angle of 115 degrees, the feet spread 5-10 inches laterally and slightly over five inches anterio-posteriorly.[104]

According to Burley and Anderson, leg power is more closely related to some sports (basketball, track and swimming) than to others, and "Power as measured by the jump and reach test is an important component of athletic ability and is closely associated with athletic success."[105] Their study attempted to relate leg power to intelligence scores and athletic performance, but the correlation obtained was too low for predictive purposes.[106]

The importance of leg power in shooting was pointed out by Sharmin when he stated, "It is very important to use the legs and body so that the arm and wrist do not have to furnish all the muscle needed to get the shot to the basket."[107]

Literature Related to Flexibility

One of the early leaders in flexibility measurement was Cureton who devised a test of flexibility which included: trunk flexion, trunk extension, shoulder elevation, and ankle flexion. For the trunk and

---

[104] Thomas P. Martin and G. Alan Stull, "Effects of Various Knee Angle and Foot Spacing Combinations in Performance in the Vertical Jump," Research Quarterly, 40:324-330, May, 1969.

[105] Lloyd R. Burley and Roy Anderson, "Relation of Jump and Reach Measures of Power to Intelligence Scores and Athletic Performance," Research Quarterly, 26:28-34, March, 1955.

[106] Ibid.

[107] Sharmin, op. cit., p. 40.

shoulder measurements, Cureton used a linear system of measurement employing sliding calipers. Ankle flexion was measured by measuring the distances between two marks on the paper representing the flexed and extended positions. Cureton standardized his tests and established percentile rankings. His test is not considered to be a truly valid measure.[108]

Another device for measuring flexibility was developed by Hawley. Her device, called a spinal flexometer, was used specifically for dealing with spinal defects. The measurements were taken in degrees with the use of a modified protractor, which did not provide for accurate measurement.[109]

Benson measured flexion and extension of knee and ankle, and abduction of the shoulder using a 360 degree protractor. His measures were also used for treatment of injuries, and therefore, no records of normal use were kept.[110]

The first instrument to measure several joints for flexibility was a flat circular dial developed by Leighton in 1941. His flexometer, as it was called, consisted of a dial 4 1/2 inches in diameter, marked off in degrees (360), and a weighted needle. To operate effectively, the dial

---

[108]Thomas K. Cureton, "Flexibility as an Aspect of Physical Fitness," Supplement to Research Quarterly, 12:381-390, May, 1941.

[109]Gertrude Hawley, Kinesiology of Corrective Exercise (Philadelphia: Lea and Febiger, 1937), p. 131.

[110]Simon Benson, "The Relative Value of Different Forms of Physiotherapy, Especially Diathermy, in Treating Joints Stiffened After Athletic Injuries," Research Quarterly, 1:57-53, December, 1930.

had to be held on edge. It was mounted to a strap for fastening to a body part.[111] A revised model of the flexometer has both a weighted needle and a weighted dial.[112]

Leighton used the flexometer to study male athletes ages 10 to 18 to determine flexibility for various age groups and to compare athletes of different sports in flexibility. The subjects in his study showed a definite downward trend in flexibility from ages 10 to 16. From 16 to 18 years of age the flexibility varied. Leighton noted that this change may have been due to changes in activity and not to age. Using 16 year olds as a reference point, Leighton found swimmers and baseball players to have the highest degree of flexibility in the 30 different measures. Basketball players were high in 14 of the measures, low in 8, and average in the other 8 measures. They were found to be quite low in shoulder and ankle flexion and extension. From his results Leighton concluded that ranges of movement increase and decrease and become fixed within specific ranges conducive to the best performance of the skill involved, and flexibility is a specific factor for each joint, but can be altered through activity.[113]

Harris supported Leighton's contention when she stated, "There is no evidence that flexibility exists as a single characteristic of the

---

[111] Jack R. Leighton, "A Simple, Objective and Reliable Measure of Flexibility," Research Quarterly, 31:205-216, 1942.

[112] Mathews, op. cit., p. 269.

[113] Jack R. Leighton, "On the Significance of Flexibility for Physical Educators," Journal of Health, Physical Education and Recreation, 31:27-28, November, 1960.

human body. Thus, no one composite test or no one joint action measure can give a satisfactory index of the flexibility characteristics of an individual."[114] She continued by observing that, "The Leighton flexometer appears to be the most objective instrument for measuring joint action."[115] In her review of literature she reported that many of its users found it to be highly valid with reliability estimates of .889 to .997.[116]

Montoye also believed flexibility to be specific for each of the various joints of the body and each of the sexes.[117]

Mathews states that the validity of the flexometer is based upon the clearly recognized and defined joint movement. Using the test-retest method, Mathews found reliability coefficients ranging from .913 to .996.[118]

Montoye reported that Forbes obtained reliability coefficients ranging from .901 to .983 when the flexometer was used for thirty different flexibility measures in a test-retest situation.[119]

---

[114] Margaret L. Harris, Ph. D., "Flexibility," Physical Therapy, 49:591-600, June, 1969.

[115] Ibid.

[116] Ibid.

[117] Henry J. Montoye, ed., An Introduction to Measurement in Physical Education (Indianapolis, Indiana, Phi Epsilon Kappa Fraternity, 1970), Volume 4, p. 68.

[118] Mathews, op. cit., pp. 269-270.

[119] Montoye, op. cit., p. 93.

In a study using some of the best shooters on the east coast (coaches' opinions), Scolnick found, through the use of cinematographic analysis, that as the distance from the basket increased, the angle of the wrist on the follow-through was also increased. This seemed to indicate the need for greater wrist flexibility to be successful on longer jump shots.[120]

Literature Related to Agility

Historically, agility was thought to be determined by heredity, but more recent studies show that it can be improved through practice. A review of the literature indicates the importance of agility as a factor in predicting sports ability and its particular importance to performance in basketball.[121]

Gates and Sheffield noted that tests of agility are either tests which include running or those which do not. Running tests were either shuttle or obstacle type. In their study using junior high boys, they used three batteries of tests which involved change of direction. These included obstacle run, shuttle run, and side stepping drills.[122]

Beise and Peasley, in their study on agility and reaction time in skilled and unskilled women, found that a seven-week training period did

---

[120] Anthony Scolnick, "An Electrogoniometric and Cinematographic Analysis of the Arm Action of Expert Basketball Jump Shooters" (unpublished Doctoral dissertation, Springfield College, Springfield, Massachusetts, 1967), pp. 1-234.

[121] Johnson and Nelson, op. cit., pp. 113-114.

[122] Donald D. Gates and R. P. Sheffield, "Tests of Change of Direction as Measurements of Different Kinds of Motor Ability in Boys of the Seventh, Eighth, and Ninth Grades," Research Quarterly, 11:140-147, October, 1940.

not significantly change the original scores. From this they concluded that reaction time, speed and agility seemed to be fundamental to skill in certain sports activities.[123]

McCloy and Young found that high scores in selected agility tests such as those in the Brace tests and Iowa Brace test, correlate highly with sports ability.[124]

In 1954 Cumbee, in a study of motor coordination, did a factoral analysis of agility tests. In this study, reluctance was shown to calling the Burpee test a "quick change of direction factor," because it did not correlate very highly with that factor. Cumbee felt that tests such as the zig-zag, sidestep, and dodging run would be more representative of the quick change of direction factor.[125]

Bennett researched the contribution of dance, basketball and swimming to motor ability. In this test, using college women as subjects, the Burpee test was used as a test of agility. Although swimming, basketball and modern dance were superior to folk dance in developing agility, no significant difference among the three sports could be found.[126]

Hilsendager, Strow, and Ackerman conducted a study in 1969 to determine whether exercises designed specifically to develop strength and

---

[123]Beise and Peasley, loc. cit.

[124]McCloy and Peasley, loc. cit.

[125]Francis Z. Cumbee, "Factoral Analysis of Motor Coordination," Research Quarterly, 25:418, December, 1954.

[126]C. Bennett, "Relative Contribution of Modern Dance, Folk Dance, Basketball and Swimming to Motor Abilities of College Women," Research Quarterly, 27:253-262, October, 1956.

speed were as effective for improving agility as were exercises designed specifically to develop agility. Eighty-three male college students were divided into five groups with each group having exercises designed specifically to improve either agility, strength, speed or speed and strength. The fifth group was a control group and attended lectures only. The exercise agility group was significantly better than any of the other groups in the performance of agility tests. The Illinois agility test discriminated between the agility exercise and the other treatments more exactly than scores from any other tests. From their study they concluded that agility can best be developed by programs designed for that purpose. There was also an indication of a possible factor unique to agility. They also concluded that the tests which claim to test agility do not all test the same thing.[127]

The effects of selected drills on agility improvement was investigated by Smith. Forty-nine male students from basic physical education classes were used as subjects. They were divided into five groups and randomly assigned to experimental treatments which used the McCauliff Agility Components Test. The carioca, running-hand touch and forward-backward sprint were found to be the best for developing agility.[128] Commenting on agility testing, Smith stated, "The apparent

---

127Donald R. Hilsendager, Malcom H. Strow and Kenneth Ackerman, "A Comparison of Speed, Strength, and Agility Exercises in the Development of Agility," Research Quarterly, 40:71-75, March, 1969.

128Richard C. Smith, Jr., "The Effects of Selected Drills Upon the Improvement of Agility" (unpublished Master's thesis, South Dakota State University, Brookings, 1969), pp. 1-61.

complex nature of agility makes it difficult to measure because most measurements are concerned with one basic type of change of direction."[129]

Johnson, in devising an objective basketball test, felt that agility was an important factor in sports ability and particularly in basketball performance.[130] Cozens observed that, "The ability to change direction quickly is extremely important in athletic events such as basketball, hockey, speedball, tennis and other related activities."[131] Patty, using the dodging run as a measure of agility, reported a significant difference within the successful players group.[132]

---

[129]Ibid., p. 12

[130]William L. Johnson, "Objective Basketball Tests for High School Boys" (unpublished Master's thesis, University of Iowa, Iowa City, 1934), pp. 1-87.

[131]F. W. Cozens, "The Measurement of General Athletic Ability in College Men" (unpublished Doctoral dissertation, University of Oregon, Eugene, 1928), pp. 1-95.

[132]Patty, op. cit., p. 121.

CHAPTER III

METHODS AND PROCEDURES

This chapter describes the selection of subjects, methods of securing data, and measuring of the variables of hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, wrist strength, and agility.

Source of the Data

The subjects consisted of twenty-four varsity and junior varsity basketball players at South Dakota State University. All of the players had been in the basketball program for at least two months prior to the study. No attempt was made to separate the players into ability groups. Table I indicates the characteristics of the subjects.

Measurement of the Criterion

Each subject shot a total of 150 jump shots from five different angles on the floor and at two distances along each angle. The angles used were: 0 degrees right, 45 degrees right, 90 degrees, 45 degrees left, and 0 degrees left. The distances were 10 and 21 feet along each angle. Fifteen shots were taken from each of the 10 spots. The shots were taken on three different days with the subject shooting 45, 60, and 45 shots respectively on each day. The order in which the subjects shot from each spot was randomly assigned. As long as a jump shot was taken from the marked spot, each shot was scored as being made or missed. The subject's score was the total number of shots made in the 150 attempts.

TABLE I

CHARACTERISTICS OF THE TWENTY-FOUR SUBJECTS

Subject	Age	Height	Weight	Playing Position
1. T.S.	18	5' 10"	160	Guard
2. D.K.	18	6' 2"	170	Guard
3. K.M.	18	6' 4"	180	Forward
4. D.S.	18	6' 0"	175	Forward
5. S.C.	18	6' 1"	165	Guard
6. P.M.	18	6' 2"	175	Forward
7. R.O.	18	5' 10"	150	Guard
8. M.S.	18	6' 0"	160	Guard
9. J.H.	18	6' 2"	170	Forward
10. T.W.	20	6' 3"	180	Forward
11. D.W.	18	5' 11"	175	Guard
12. J.N.	19	6' 4"	175	Forward
13. T.P.	19	6' 4"	185	Forward
14. C.B.	20	6' 7"	190	Center
15. J.M.	21	6' 4"	170	Guard
16. J.J.	21	6' 7"	220	Center
17. D.T.	20	6' 6"	200	Forward
18. R.H.	21	6' 5"	195	Forward
19. R.G.	19	6' 0"	170	Guard
20. D.N.	20	6' 8"	230	Center
21. J.H.	21	6' 2"	180	Guard
22. R.W.	19	6' 0"	170	Guard
23. L.C.	20	6' 6"	205	Forward
24. E.F.	19	6' 6"	185	Forward

Collection of the Data for the Independent Variables

The variables used in the study were selected on the basis of their possible relationship to jump shooting ability in basketball. The data collected consisted of the subject's scores in the areas of hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, wrist strength, and agility. The entire testing program was administered to each subject once. Testing began on February 18, 1972 and ended on March 2, 1972. The following sections indicate the methods followed to collect the data.

Measurement of hand-eye coordination. To test hand-eye coordination, the wall-pass test was used. The subject stood behind a restraining line nine feet from the wall with a basketball in his hands. On the command, "begin", the subject threw the ball against the wall and caught it as it rebounded, and continued to throw and catch the ball for fifteen seconds when the signal to stop was given. If the ball was dropped or did not rebound to the subject's hands, he recovered it, returned to the restraining line, and continued to throw until the time limit had expired.[1] Three trials were given, with the recorded score being the mean of the number of times the ball was caught after striking the wall. To be counted, the ball must have been caught with both feet behind the restraining line. The trial periods were spaced at least three minutes apart.

---

[1]Barry L. Johnson and Jack K. Nelson, Practical Measurements in Physical Education (Minneapolis: Burgess Publishing Company, 1970), p. 124.

<u>Measurement of hand reaction time</u>. The Nelson Hand Reaction Test was used to measure the speed of reaction of the hand to a visual stimulus. The subject was seated in a desk with his forearm and hand resting comfortably on the desk top and the tips of his thumb and index finger held about three or four inches beyond the edge in a ready-to-pinch position (approximately one inch apart). The upper edges of the thumb and forefinger were held in a horizontal position. Holding the stick timer near the top, the tester let it hang between the subject's thumb and index finger with the Base Line kept even with the upper surface of the subject's thumb. The subject was directed to look at the Concentration Zone (a black shaded area on the timer stick between .120 and .130 record lines) and to react by catching the stick (by pinching the thumb and index finger together) when it was released. The subject was not allowed to look at the tester's hand or move his hand up or down while attempting to catch the falling stick. Each drop was preceded by the preparatory command of "ready." When the subject caught the stick timer, the score was read just above the upper edge of the thumb. The numbers of the timer represent hundredths of a second. Each score was recorded to the nearest one-hundredth of a second. Twenty trials were given with the five fastest and five slowest times being discarded and the average middle ten recorded as the score.[2]

---

[2]Ibid., p. 230.

Measurement of speed of movement time. The Nelson Speed of Movement Test was used for this test. The subject was instructed to sit facing a table with his fingers resting on the edge of the table. The palms were facing each other and positioned with the inside edge of the little fingers along two lines spaced twelve inches apart. The Nelson Reaction Timer was held by the tester near its top so that it hung at a point midway between the subject's palms. The Base Line was held in a position level with the upper edge of the subject's hands.

After the preparatory command of "ready," the stick timer was released and the subject attempted to stop its fall as quickly as possible by clapping his hands together. The tester made sure that the subject did not move his hands up or down or look at the tester's hands. The subject was given twenty trials with his score being the mean of the middle ten trials after the five fastest and five slowest trials had been discarded.[3] Each score was recorded to the nearest one-hundredth of a second.

Measurement of hand size. Hand size was measured for both length and width on the metric scale to the nearest centimeter. For the measurement of the length, the tester instructed the subject to wet his hand on the wet towel provided, and put his hand print on the blackboard. He was instructed to keep his arm, as close as possible, at a 90 degree angle. A chalk mark was then placed at the upper and lower extremes of

---

[3]Ibid.

the hand print. The distance between the two chalk marks was recorded to the nearest millimeter. Only the shooting hand of the subject was measured.

For the measurement of the width, a vernier caliper was used. The subject was instructed to lay his hand flat on a table. The measurement was taken across the back of the hand from the knuckle of the index finger to the knuckle of the little finger. The measurements were recorded to the nearest millimeter. The final hand size which was recorded consisted of the sum of the width and length of the shooting hand.[4]

Measurement of grip strength. A T-5 cable tensiometer apparatus was used to measure grip strength. This device is an instrument which measures the tension applied on a cable by the gripping action of the subject. The tension of the wire is recorded on a dial which has two hands, one remaining at the maximum score and the other returning to zero. The maximum score, as indicated by the needle, is recorded to the nearest whole number and then converted to pounds by a conversion table.

The subject having been orientated to the use of the tensiometer, stood with good balance, knees slightly flexed, the elbow of the shooting arm bent at a 90 degree angle and the forearm parallel to the floor.[5] With his non-shooting hand he gripped the wrist of the hand being tested

---

[4]Marlin P. Vis, "The Relationship of Forward Pass Catching Ability in Football and Selected Anatomical Measurements and Motor Responses" (unpublished Master's thesis, South Dakota State University, Brookings, 1971), p. 38.

[5]George Greey and Rod Hunsicker, "Studies in Human Strength," Research Quarterly, 28:111-118, May, 1959.

to hold it at the 90 degree angle. The tensiometer was gripped with the palm of the hand facing upward. The subject gave one maximum contraction and the reading was recorded. Three trials were given with the best score being recorded as the grip strength for that hand. Only the shooting hand was measured. Care was taken to eliminate any outside factors that might influence the results of the test.

Measurement of peripheral vision. The apparatus for measuring peripheral vision consisted of a flat half circle with a radius of 30 inches. It was placed on the eye level of the subject on a horizontal plane. The surface of the apparatus was painted dull white. On the edge of the half circle were two rods, painted dull black, which could be moved along the edge by means of levers. The subject fitted his head into a notch in the flat side of the half circle so that his eyes were level with the platofrm and fixed on a point directly ahead of the edge of the platform.

The tester sat in front of the subject and controlled the levers which moved the rods. The tester moved one of the rods slowly toward the fixed point until the subject gave the command to stop, indicating that he had observed the rod in his periphery. The subject then indicated to which side the rod was located. If correct, the angle between the fixed point and the rod was recorded in degrees. If incorrect, the tester returned the rod to its starting position and began the test again. Incorrect trials were disregarded.[6] The subject was given ten trials,

---

[6]Vis, op. cit., p. 41.

five on each side, with the order for moving the rods being randomly selected.[7] His score was the mean angle of the ten trials.

Measurement of depth perception. A modification of the Howard-Dolman apparatus was used to measure depth perception. It consisted of a box 24 inches long, 11-3/4 inches wide, and 12-1/2 inches high, open at the sides and top. At the end of the box nearest the subject was a rectangular window three inches high and 7-1/2 inches wide. Two vertical rods were positioned inside the box. One was stationary at the center of the box and the other was free to move lengthwise on a track. The rods were two inches apart when positioned at their closest point. The movable rod was controlled by strings which were given to the subject at the beginning of the test. A millimeter scale was placed next to the movable track with its center point (marked 0) placed directly opposite the fixed rod. The scale's range was from 0 to 200 millimeters toward the observer and 0 to 200 millimeters away from the observer.[8]

After the test was explained to the subject, he was allowed to look at the instrument, manipulate the strings, and ask questions about the procedure. He was then seated in a chair 20 feet away from the apparatus and the test began. At the beginning of each trial, the tester

---

[7]Robert A. Cobb, "A Comparative Study of Color Recognition in the Peripheral Field of Vision of Participants in Selected Sports" (unpublished Master's thesis, Springfield College, Springfield, Massachusetts, 1967), p. 22.

[8]Elsa M. Hermerer, "A Study of the Relationship Between Visual Depth Perception and General Tennis Ability" (unpublished Master's thesis, University of North Carolina, Greensoro, 1968), p. 24.

would stand in front of the instrument (to hide it from the subject's view) and set the movable rod at the extreme front or back, according to a predetermined pattern. The subject was then instructed to line up the two rods directly opposite each other. The score for each trial was the number of millimeters the movable rod deviated from the fixed rod. The subject's depth perception was the mean of ten trials measured to the nearest whole millimeter.[9]

Measurement of kinesthetic perception. Two tests were used to measure kinesthetic perception. One of these was the balance stick test. The balance stick, which is a wooden stick one inch square and twelve inches long, was taped securely to the floor. The tester gave a demonstration along with the following directions:

> Stand with one foot lengthwise on the stick. When your foot is secure, close your eyes and lift the other foot off the floor and hold your balance as long as possible. You may do anything you like as long as you do not touch the floor with any part of your body or open your eyes. You will be timed from the moment you lift your foot from the floor until you open your eyes or touch the floor. You may have one practice with your right foot and three test trials, and then one practice with your left foot and three test trials. Then there will be three more trials on each foot. Your score will be the total time on 12 trials.[10]

The total score was recorded to the nearest tenth of a second.

---

[9] H. W. Seiger, "Variation in Illumination of the Depth Perception Apparatus," Journal of Aviation Medicine, 15:410-403, December, 1955.

[10] Gladys M. Scott, Analysis of Human Motion (New York: F. S. Crofts and Company, 1942), p. 101.

The second test administered was the arm-raising test. The subject was instructed to stand with his back pressed against the Deming posture chart and arms at his sides. The following verbal directions were given: "Close your eyes and raise your right arm out sideward to a horizontal position with the palm facing down."[11] After the subject raised his arm to an angle he perceived to be 90 degrees from his body, the tester, facing the subject, made one mark on the Deming posture chart even with the acromion process of the scapula of the shoulder. Another mark was made even with the protruding condyle of the ulna bone near the little finger. These two marks were then connected by a straight line. A straight line parallel with the floor was then drawn using the mark made even with the acromion process and the squares on the posture chart. The degrees of deviation were determined by use of a goniometer and recorded as degrees of deviation from the horizontal. The test was repeated twice for each arm. The sum of the deviations of the four trials, in degrees, was the score recorded. A score of zero represented a perfect score.[12]

Measurement of leg power. The Sargent Jump test was used to measure leg power. The subject was instructed to stand with one side toward a wall on which was mounted a chalkboard. He was then told to raise the arm nearest the wall while keeping his heels together and standing on

---

[11]Ibid.

[12]Vis, op. cit., p. 47.

his toes. A sliding yardstick mounted on the chalkboard was moved until the end marked 0 inches was even with the tip of the index finger. The performer then chalked his fingers, crouched, and then jumped as high as possible and touched the chalkboard next to the yardstick with his chalked fingers. The number of inches was then read from the ruler and recorded to the nearest quarter of an inch. The subject's score was the best score of three trials.[13]

Measurement of wrist flexibility. The Leighton Flexometer was used to measure wrist flexibility. The flexometer consists of a weighted dial, marked off in degrees (360), and a weighted pointer, both of which are free to move about a central fixed point. The flexometer fastened to the body part being tested by means of an adjustable strap.

The subject was seated in a chair with his back straight and his forearm resting on the corner of the table. His hand was clenched and extended beyond the edge of the table with the palm up. The flexometer was fastened to the thumbside of the fist. The subject was then instructed to move his fist upward in an arc as far as possible (wrist flexion). The tester then locked the dial. The subject then moved his hand forward (wrist extension) and downward in an arc as far as possible (wrist hyperextension). The pointer was then locked. The subject was allowed to relax and the reading was taken at the pointer to the nearest

[13]Johnson and Nelson, op. cit., p. 81.

degree. The tester made certain that the subject did not raise his forearm from the table during the flexion or hyperextension of his wrist.[14] Three trials were given with the subject's score being the mean of the three trials.

Measurement of wrist flexion strength. A cable tensiometer was used to measure wrist flexion strength. The subject was seated in a desk chair with his ball-shooting hand extended beyond the edge of the desk, palm upward. The cable was fastened to a board on the floor directly below the subject's hand. His hand was slipped into a strap fastened to the cable. The length of the cable was adjusted so that the hand was hyperextended to an angle of 45 degrees (measured by a goniometer), which closely approximates the angle of his wrist at the start of the release of the ball during a shot.[15] The tensiometer was clamped to the cable and the subject, with his hand supinated, was instructed to clench his hand around the strap and apply maximum force on the cable by the flexion of his wrist. Care was taken to make sure that the subject did not raise his forearm from the desk during contraction. The subject gave a maximum contraction and the reading was recorded. His score was the best score of three trials.

---

[14]Henry J. Montoye, ed., An Introduction to Measurement in Physical Education (Indianapolis: Phi Epsilon Kappa Fraternity, 1970), p. 107.

[15]Anthony Scolnick, "An Electrogoniometric and Cinematographic Analysis of the Arm Action of Expert Basketball Jump Shooters" (unpublished Doctoral dissertation, Springfield, Massachusetts, 1967), pp. 1-234.

Measurement of agility. Agility was measured by the side-step test. Two lines eight feet apart were marked on the basketball court. The subject started from a standing position straddling a line midway between the two lines. At the starting signal the subject shuffled to the right until his right foot was beyond the line, and then quickly shuffled back across the area until his left foot touched outside the other line eight feet from the first line. He then shuffled back across to the right. The subject continued at as rapid a pace as possible until the ten second time limit had expired.[16] The subject's score for each trial was the number of times that he crossed the middle line on the court. Two trials were given with the subject's best score being recorded.

Procedure for Collection of the Data

The investigator conducted the tests that were administered to the subjects with the aid of fellow-graduate assistants when more than one subject came to take the test during one testing period. Each of these testers was thoroughly instructed in the mechanics of administering the test and was given several trials to become familiar with the testing equipment. A three day testing period was established with the subjects coming in at times convenient to their schedules to take the tests. For the most part the tests that were given were not closely enough related for learning or fatigue to occur. Therefore, the order in which the subjects took the tests was not fixed with the exception of such test items

[16]Johnson and Nelson, op. cit., p. 103.

as wrist strength and grip strength. These were not give in succession because of the possibility of fatigue effects. The subjects did not necessarily complete all of the tests during one testing period. In some cases the subject's schedule was such that he could only take a few tests each day and therefore it took him all three testing days in order to obtain all the data on the independent variables for him.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

Organization of the Data for Treatment

The investigator identified thirteen independent variables as being possible contributors to success in jump shooting. The independent variables measured were hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, wrist strength, and agility. The three dependent variables were the number of jump shots made from 10 feet (75 attempts), the number of jump shots made from 21 feet (75 attempts), and the total number of jump shots made of the 150 attempts. The means and standard deviations for the thirteen independent and three dependent variables are found in Table II. Appendix A contains the raw data for the variables.

To make it possible to predict jump shooting ability on the basis of the thirteen selected independent variables, a multiple correlation and regression statistical procedure was used.[1] The first step in this procedure was to compute the intercorrelations between all of the independent variables and the correlation between the independent and dependent variables. The multiple regression equations were then developed beginning with a one variable equation and adding one additional variable in each of

[1]Henry E. Garrett, Statistics in Psychology and Education (New York: Longmans, Green and Company, 1958), pp. 403-404.

TABLE II

MEANS AND STANDARD DEVIATION OF MEASUREMENTS FROM THE TWENTY-FOUR BASKETBALL PLAYERS IN THE STUDY

	Measurements	Mean	Standard Deviation
X_1	Wrist Strength (pounds)	63.048	15.012
X_2	Eye-Hand Coordination (repetitions)	17.483	1.689
X_3	Leg Power (inches)	24.792	2.646
X_4	Balance Stick (seconds)	61.496	20.432
X_5	Hand Size (centimeters)	28.142	1.259
X_6	Agility (repetitions)	12.417	1.717
X_7	Grip Strength (pounds)	122.333	14.678
X_8	Speed of Movement (seconds)	.223	.016
X_9	Hand Reaction (seconds)	.165	.011
X_{10}	Flexibility (degrees)	128.592	13.706
X_{11}	Arm Raise (degrees)	10.500	5.246
X_{12}	Peripheral Vision (degrees)	93.283	2.250
X_{13}	Depth Perception (centimeters)	17.233	12.394
Y_T	Total Shots Made	85.750	12.976
Y_{21}	Shots Made at 21 Feet	34.250	8.373
Y_{10}	Shots Made at 10 Feet	51.500	6.093

the following steps to increase the accuracy of the predictions. A standard error of estimate, multiple correlation, and variance accounted for in that step were also computed for each step in the equation. To increase the accuracy and speed of this process, an electronic computer was used.

Analysis of the Data

Table III shows the matrix of zero order correlations. Fifteen of the 78 intercorrelations were significant beyond the .05 level of confidence. Four of the thirteen independent variables showed a significant correlation, beyond the .05 level of confidence, with jump shooting ability. Of these four, only wrist strength correlated to all three of the dependent variables. It showed a correlation of -.42 with jump shooting ability at 10 feet, -.45 with jump shooting ability at 21 feet, and -.49 with total jump shooting ability. Wrist flexibility correlated .48 with jump shooting ability at 10 feet and .42 with total jump shooting ability. Hand reaction time showed correlations of -.53 with jump shooting ability at 21 feet and -.47 with total jump shooting ability. A correlation of -.42 was found between hand size and jump shooting ability at 21 feet.

The developed regression equations are shown in Tables IV, V, and VI. Table IV contains the developed regression equation for jump shooting ability at 10 feet. According to the variance accounted for by the addition of each new variable to the equation, only the first two variables made a significant contribution to the equation ($186.351 \gg 142.62$). The variance accounted for by the addition of variables beyond the first two was not significant ($53.596 < 142.62$; $31.494 < 142.62$; etc.). This would

TABLE III

CORRELATION MATRIX

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	Y_T	Y_{21}	Y_{10}
1	1.00	.27	.31	.14	.11	.29	.38	-.05	.19	.10	-.26	.38	-.28	-.49*	-.45*	-.42*
2		1.00	.15	-.05	.12	.53**	.23	-.09	-.29	.46*	-.42*	.41*	-.06	.36	.33	.32
3			1.00	.24	.52**	.38	.49*	.36	.46*	.16	-.51*	.43*	.12	-.13	-.17	-.04
4				1.00	.01	.25	-.08	.05	.26	.04	-.20	.08	-.37	-.12	-.14	-.05
5					1.00	.06	.59**	.52**	.28	.14	-.40*	.43*	-.03	-.20	-.42*	.15
6						1.00	-.10	.04	.02	.27	-.38	.23	.27	.24	.23	.20
7							1.00	.30	.04	.10	-.37	.45*	-.19	-.21	-.28	-.06
8								1.00	.62**	.28	-.14	.08	-.01	-.13	-.27	.10
9									1.00	-.08	-.22	.04	-.07	-.47*	-.53**	-.27
10										1.00	.12	.28	-.22	.42*	.30	.48*
11											1.00	-.07	-.11	.20	.19	.17
12												1.00	.08	.00	-.13	.19
13													1.00	.02	.05	-.03
Y_T														1.00	.93**	.86**
Y_{21}															1.00	.60**
Y_{10}																1.00

1 Wrist Strength
2 Eye-Hand Coordination
3 Leg Power
4 Balance Stick
5 Hand Size
6 Agility
7 Grip Strength
8 Speed of Movement
9 Hand Reaction
10 Flexibility
11 Arm Raise
12 Peripheral Vision
13 Depth Perception
Y_T Total shots made
Y_{21} Shots made 21 feet
Y_{10} Shots made 10 feet

* $r_{.05}(22) = .40$

** $r_{.01}(22) = .52$

seem to indicate the use of an equation between numbers 2 and 13 depending upon the amount of time and accuracy desired. If time was a factor, equation 2 should be used to predict shooting ability at 10 feet. However, if accuracy was foremost, then any equation beyond equation 2 could be used.

The developed regression equation for jump shooting ability at 21 feet is shown in Table V. A look at the variance accounted for by the addition of each new variable to the equation reveals that the first 8 variables make a significant contribution to the equation ($109.976 \geqslant 108.67$). The variance accounted for by the addition of variables beyond the first 8 was not significant ($26.687 < 108.67$; $5.428 < 108.67$; etc.). Since the variance accounted for reaches its most significant point in equation 8, at least 8 variables are needed for prediction of jump shooting ability at 21 feet.

Table VI contains the developed regression equation for total jump shooting ability. Checking the variance accounted for by the addition of each new variable to the equation we find that only the first two variables make a significant contribution to the equation ($1026.889 \geqslant 344.67$). Beyond the second variable the variance accounted for by the addition of variables was not significant ($205.044 < 344.67$; $131.477 < 344.67$; etc.). Therefore, this would seem to indicate the use of an equation between numbers 2 and 13 depending upon time and accuracy desired. If time was a factor, equation number 2 should be used to predict total jump shooting ability. However, if accuracy was desired, then any equation beyond number 2 could be used.

TABLE IV

REGRESSION EQUATIONS DEVELOPED, THEIR STANDARD ERRORS OF ESTIMATE, MULTIPLE CORRELATION, AND VARIANCE ACCOUNTED FOR BY THE ADDITION OF EACH VARIABLE

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1. $Y_{10} = .213X_{10} + 24.092$	5.468	.479	196.281
2. $Y_{10} = .233X_{10} - .422X_1 + 37.766$	4.738	.669	186.351
3. $Y_{10} = .240X_{10} - .512X_1 + .761X_{12} - 25.783$	4.570	.715	53.596
4. $Y_{10} = .183X_{10} - .556X_1 + .716X_{12} + .738X_6 - 26.389$	4.509	.740	31.494
5. $Y_{10} = .136X_{10} - .679X_1 + .918X_{12} + 1.203X_6 - .144X_{13} - 37.374$	4.337	.777	47.680
6. $Y_{10} = .104X_{10} - .736X_1 + 1.046X_{12} + 1.702X_6 - .230X_{13} - .080X_4 - 43.174$	4.186	.807	40.745
7. $Y_{10} = .103X_{10} - .715X_1 + 1.032X_{12} + 1.650X_6 - .223X_{13} - .071X_4 - 48.198X_9 - 34.639$	4.273	.811	5.758
8. $Y_{10} = .108X_{10} - .718X_1 + 1.106X_{12} + 1.839X_6 - .238X_{13} - .079X_4 - 59.891X_9 - .316X_2 - 36.195$	4.393	.813	2.647
9. $Y_{10} = .108X_{10} - .711X_1 + 1.051X_{12} + 1.823X_6 - .234X_{13} - .077X_4 - 67.046X_9 - .315X_2 + .194X_5 - 35.658$	4.539	.814	0.964

TABLE IV (Continued)

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
10. $Y_{10} = .110X_{10} - .704X_1 + 1.065X_{12} + 1.845X_6 - .229X_{13} - .074X_4 - 59.481X_9 - .313X_2 + .272X_5 - .106X_3 - 38.824$	4.704	.814	0.801
11. $Y_{10} = .113X_{10} - .707X_1 + 1.058X_{12} + 1.848X_6 - .228X_{13} - .075X_4 - 52.481X_9 - .316X_2 + .315X_5 - .111X_3 - 7.76X_8 - 38.975$	4.895	.814	0.115
12. $Y_{10} = .115X_{10} - .711X_1 + 1.05X_{12} + 1.867X_6 - .227X_{13} - .074X_4 - 48.430X_9 - .324X_2 + .306X_5 - .127X_3 - 10.180X_8 + .011X_7 - 39.046$	5.113	.814	0.029
13. $Y_{10} = .115X_{10} - .711X_1 + 1.052X_{12} + 1.866X_6 - .227X_{13} - .074X_4 - 48.130X_9 - .319X_2 + .309X_5 - .126X_3 - 10.33X_8 + .012X_7 + .002X_{11} - 39.020$	5.362	.814	0.001

*Total Variance = 854.0

MS Variance = 28.754

$F_{.05}$ (1/10) = 4.96

LSD = 28.754 x 4.96 = 142.62

TABLE V

REGRESSION EQUATIONS DEVELOPED, THEIR STANDARD ERRORS OF ESTIMATE, MULTIPLE CORRELATION, AND VARIANCE ACCOUNTED FOR BY THE ADDITION OF EACH VARIABLE

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1. $Y_{21} = -399.116X_9 + 100.154$	7.266	.529	450.901
2. $Y_{21} = -345.901X_9 - .452X_1 + 108.882$	6.738	.639	208.149
3. $Y_{21} = -334.607X_9 - .590X_1 + 1.830X_6 + 89.658$	6.107	.733	207.620
4. $Y_{21} = -275.964X_9 - .574X_1 + 1.892X_6 - 1.938X_5 + 133.101$	5.712	.785	125.887
5. $Y_{21} = -246.984X_9 - .586X_1 + 1.552X_6 - 2.232X_5 + .170X_{10} + 119.376$	5.311	.828	112.167
6. $Y_{21} = -316.228X_9 - .627X_1 + 1.133X_6 - 2.982X_5 + .164X_{10} + .905X_3 + 137.122$	5.103	.852	65.025
7. $Y_{21} = -339.161X_9 - .753X_1 + 1.625X_6 - 3.056X_5 + .114X_{10} + 1.083X_3 - .171X_{13} + 146.682$	4.828	.877	69.845
8. $Y_{21} = -297.290X_9 - .854X_1 + 2.368X_6 - 3.430X_5 + .073X_{10} - 1.371X_3 - .315X_{13} - .139X_4 + 154.184$	4.187	.915	109.976
9. $Y_{21} = -268.985X_9 - .951X_1 - 2.535X_6 - 3.845X_5 + .044X_{10} + 1.290X_3 - .360X_{13} - .155X_4 + .668X_{12} + 108.099$	4.090	.925	28.687

TABLE V (Continued)

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
10. $Y_{21} = -261.400X_9 - .973X_1 + 2.435X_6 - 4.058X_5 + .054X_{10} + 1.203X_3 - .364X_{13} - .159X_4 + .770X_{12} - .130X_{11} + 107.816$	4.195	.926	5.428
11. $Y_{21} = -300.461X_9 - .960X_1 + 2.422X_6 - 4.308X_5 + .037X_{10} + + 1.227X_3 - .369X_{13} - .157X_4 + .817X_{12} - .138X_{11} + + 43.247X_8 + 108.578$	4.333	.928	3.544
12. $Y_{21} = -360.117X_9 - .913X_1 + 2.189X_6 - 4.281X_5 + .023X_{10} + 1.411X_3 - .390X_{13} - .165X_4 + .935X_{12} - 192X_{11} + 78.638X_8 - .159X_7 + 108.904$	4.472	.929	5.273
13. $Y_{21} = -369.371X_9 - .926X_1 + 2.304X_6 - 4.387X_5 + .031X_{10} + 1.378X_3 - .407X_{13} - .174X_4 + 1.054X_{12} - .254X_{11} + 80.350X_8 - .163X_7 - .282X_2 + 107.460$	4.681	.930	0.897

*Total Variance = 1612.5

MS Variance = 21.91

$F_{.05}$ (1/10) = 4.96

LSD = 21.91 x 4.96 = 108.67

TABLE VI

REGRESSION EQUATIONS DEVELOPED, THEIR STANDARD ERRORS OF ESTIMATE, MULTIPLE CORRELATION, AND VARIANCE ACCOUNTED FOR BY THE ADDITION OF EACH VARIABLE

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1. $Y_T = -.936X_1 + 122.009$	11.572	.489	926.370
2. $Y_T = -1.215X_1 + 4.113X_2 + 60.934$	9.560	.710	1026.889
3. $Y_T = -1.119X_1 + 5.045X_2 + .799X_{11} + 32.496$	8.929	.767	324.605
4. $Y_T = -1.190X_1 + 4.148X_2 + .919X_{11} + 2.114X_6 + 23.433$	8.552	.801	205.044
5. $Y_T = -1.344X_1 + 3.730X_2 + .846X_{11} + 2.866X_6 - .244X_{13} + 32.022$	8.360	.822	131.477
6. $Y_T = -1.282X_1 + 2.825X_2 + .665X_{11} + 3.141X_6 - .256X_{13} - 232.020X_9 + 82.774$	8.229	.838	107.023
7. $Y_T = -1.344X_1 + 2.851X_2 + .852X_{11} + 2.804X_6 - .280X_{13} - 331.570X_9 + 1.162X_3 + 74.993$	8.028	.857	119.833
8. $Y_T = -1.409X_1 + 2.196X_2 + .747X_{11} + 3.646X_6 - .407X_{13} - 327.956X_9 + 1.254X_3 - .121X_4 + 86.332$	7.979	.868	76.275
9. $Y_T = -1.459X_1 + 2.236X_2 + .626X_{11} + 3.503X_6 - .448X_{13} - 312.409X_9 + 1.758X_3 - .148X_4 - 2.068X_5 + 136.096$	7.821	.883	98.564

TABLE VI (Continued)

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
10. $Y_T = -1.699X_1 + .556X_2 + .153X_{11} + 4.457X_6 - .623X_{13} - 313.517X_9 + 1.372X_3 - .228X_4 - 3.404X_5 + 1.664X_{12} + 68.035$	7.680	.896	89.684
11. $Y_T = -1.689X_1 - .541X_2 - .181X_{11} + 4.376X_6 - .606X_{13} - 326.340X_9 + 1.065X_3 - .240X_4 - 3.872X_5 + 1.929X_{12} + .172X_{10} + 67.803$	7.649	.905	64.595
12. $Y_T = -1.678X_1 - .555X_2 - .191X_{11} + 4.372X_6 - .611X_{13} - 359.319X_9 + 1.083X_3 - .239X_4 - 4.086X_5 + 1.974X_{12} + .158X_{10} + 36.114X_8 + 68.362$	7.975	.905	2.469
13. $Y_T = -1.636X_1 - .601X_2 - .252X_{11} + 4.170X_6 - .634X_{13} - 417.498X_9 + 1.251X_3 - .248X_4 - 4.077X_5 + 2.106X_{12} + 146X_{10} + 70.019X_8 - .151X_7 + 68.439$	8.336	.906	4.784

*Total Variance = 3872.5

MS Variance = 69.49

$F_{.05}$ (1/10) = 4.96

LSD = 69.49 x 4.96 = 344.67

Discussion of Results

In correlating the 13 independent variables to the three dependent variables, this investigator found 8 correlations that were significant beyond the .05 level of confidence. Correlating with jump shooting ability at 10 feet were wrist strength (-.42) and wrist flexibility (.48). Jump shooting ability at 21 feet correlated with wrist strength (-.45), hand size (-.42) and hand reaction time (-.53). Wrist strength (-.49), hand reaction time (-.47), and wrist flexibility (.42) correlated with total jump shooting ability. Studying these correlations we can see that variables which appear to be important at 10 feet may not be important at 21 feet or vice versa.

The correlations between wrist strength and jump shooting ability at 10 feet (-.42) and at 21 feet (-.45) were rather surprising. Although no studies were found in which wrist strength, in relation to shooting, was measured, some players known for their basketball ability felt that it was important.[2,3] Because of the negative correlations, it is apparent that wrist strength is not needed in shooting the jump shot and, in fact, may be a hindrançe. Apparently muscles, other than those in the wrist, work together to supply the power to deliver the ball to the basket. The fact that grip strength showed a negative correlation also (-.28 at 21 feet) seems to support this finding.

---

[2]Bob Cousy, Basketball Concepts and Techniques (Boston: Allyn and Bacon, Inc., 1970), p. 39.

[3]Bill Sharmin, Sharmin on Basketball Shooting (Englewood Cliffs: Prentice-Hall, Inc., 1965), p. 40.

The significant positive correlation between wrist flexibility and total shots made (.42) may help to explain this phenomenon. Results of other studies seem to indicate that a decrease in flexibility occurs as strength and bulk of muscles around joints increase.[4,5] If this were the case, then shooters with weaker wrists and more wrist flexibility would be more effective jump shooters at both 10 and 21 feet since the total correlation for wrist flexibility was significant (.42). However, these players would probably be the most effective at 10 feet where the highest correlation was found (.48). In studying jump shooters, Scolnick found that the wrist angle at the start of the shot was the same for 9, 15, and 21 feet, but greater wrist flexion was found at the completion of the shot at 21 feet than at the other two distances.[6]

Hand reaction time as measured by the Nelson Reaction Timer showed the highest correlation of any of the variables. But, here again a difference was found between the correlations at 10 feet (-.27) and at 21 feet (-.53). At 10 feet the quickness of the hand does not appear to be as important as at 21 feet. Several studies completed on basketball

---

[4]Herman J. Tyrance, "Relationships of Extreme Body Types to Ranges of Flexibility," Research Quarterly, 29:349-359, October, 1958.

[5]Clayne R. Jensen and Gordon W. Schultz, Applied Kinesiology (New York: McGraw-Hill Book Company, 1970), p. 354.

[6]Anthony Scolnick, "An Electrogoniometric and Cinematographic Analysis of the Arm Action of Expert Basketball Jump Shooters" (unpublished Doctoral dissertation, Springfield College, Springfield, Massachusetts, 1967), pp. 1-234.

players seemed to point toward a relationship between reaction time and shooting ability.[7,8,9] However, these studies were more concerned with general basketball ability than with shooting ability.

Hand speed of movement, although not significant, showed the same general trend at 10 and 21 feet as did hand reaction. It appears to have some importance at 21 feet (-.27), but not as much at 10 feet (.10). The significant intercorrelation (.62) between these two variables indicates why this would occur.

Hand size appears to be an important factor in jump shooting from 21 feet. At that distance the correlation shown (-.42) seems to indicate that a shooter with a smaller hand would be more effective than a shooter with a large hand. At a distance of 10 feet, the opposite would be true although the relationship is insignificant (.15). The reason for this might be the fact that the players with larger hands are generally forwards and centers, both of whom do most of their shooting at closer range and would therefore find these shots easier. The guards, who would tend to have smaller hands and do most of their shooting in practice and in games from longer distances, would probably be more adept at the distance of 21 feet. This finding would conflict with the study done by

---

[7] Lloyd R. Burley, "A Study of the Reaction Time of Physically Trained Men," Research Quarterly, 15:232-235, October, 1944.

[8] L. B. Keller, "The Relation of Quickness of Bodily Movement to Success in Athletics," Research Quarterly, 13:146-155, March, 1942.

[9] Elbert K. Patty, "The Relationship of Selected Measurable Traits to Success in Basketball" (unpublished Doctoral dissertation, Springfield College, Springfield, Massachusetts, 1967), pp. 1-130.

Patty whose results showed that better basketball players tended to have larger hands.[10] But, here again the relationship was with less skilled basketball players and not with shooting ability.

According to the literature reviewed by the investigator, the question of the relationship of peripheral vision and depth perception scores to shooting ability is controversial. The results of a study completed by Barclay supported the findings of this study. He concluded that a "good eye" in shooting could not be statistically supported.[11] In contrast, Cousy[12] and Sherman[13] felt that peripheral vision was important in the location of the central object. The results of this study demonstrated, however, that no correlation exists between peripheral vision and total jump shooting ability (.00).

The review of the literature indicated the possibility of a correlation between shooting ability and depth perception.[14, 15] The

---

[10]Ibid.

[11]George D. Barclay, "The Relationship Between Efficient Vision and Certain Sensory Motor Skills" (unpublished Doctoral dissertation, New York University, New York City, 1938), pp. 1-87.

[12]Cousy, loc. cit.

[13]Hoyt Sherman, "Aspects of Visual Perception and Their Relationships to Motor Activity," 53rd Annual Proceedings, College Physical Education Association (Washington: College Physical Education Association, 1959), p. 8.

[14]C. H. McCloy and Norma D. Young, Tests and Measurements in Health and Physical Education (New York: Appleton-Century-Crofts, Inc., 1954), p. 497.

[15]Joseph F. Dickson, "The Relationship of Depth Perception to Goal Shooting in Basketball," (unpublished Doctoral dissertation, State University of Iowa, Iowa City, 1934), pp. 1-90.

results of this study indicated that there was no relationship because the correlations obtained with jump shooting ability were -.03 at 10 feet, .05 at 21 feet, and .02 with total jump shooting ability. From these correlations it can be concluded that depth perception, as measured in this study, was relatively unimportant at either close or long range. A possible explanation of the difference between the results obtained in this study and those of other studies might be the type of subjects used. The subjects in this study were all successful, to some degree, in that they had been chosen for the junior varsity or varsity team. Other studies which reported depth perception as being related to success in athletics used both successful and unsuccessful athletes as subjects and compared the two groups.[16, 17]

It may be possible that depth perception becomes a more important factor when a wide range of abilities is employed. Dickson suggested that kinesthetic sense may be a possible factor in depth perception where some type of manipulation is involved, because the results of his study did not show a significant relationship between depth perception and goal shooting.[18] Sloan and Altman proposed that all tests of depth perception might be valid measures of different aspects of the visual situation. If this is true, researchers may find that depth perception is not a simple

---

[16]Samuel Winograd, "Relationship of Timing and Vision to Baseball Performance," Research Quarterly, 13:481-493, December, 1942.

[17]Ashton Graybeil, "Russian Studies of Vision in Relation to Physical Activity and Sports," Research Quarterly, 26:480-485, December, 1955.

[18]Dickson, op. cit., p. 10.

visual ability, but a highly complex and composite integration of many factors.[19]

Although it did not show a significant correlation, eye-hand coordination did show a degree of positive correlation at both 10 feet (.32) and 21 feet (.33). This would seem to indicate that eye-hand coordination could be a factor in jump shooting ability, although maybe not as important as other factors. Eye-hand coordination has been studied in relation to tests of general basketball ability and many of these tests include it as a test item. It would seem to follow that variables which attribute to general basketball ability might also be important in a specific basketball skill.

Agility was another of the variables considered to be important as a characteristic of successful basketball players.[20,21] The results of this study showed positive correlations of .20 at 10 feet and .23 at 21 feet, indicating that agility does have some relationship. The relationship may have been significant if a wider range of basketball ability had been used.

Halverson reported that learning of a shooting skill by kinesthetic perception was as effective as regular practice, suggesting that it may

---

[19]Louise L. Sloan and Adelaide Altman, "Factors Involved in Several Tests of Binocular Depth Perception," American Medical Association Archives of Ophthamology, 52:524-543, October, 1954.

[20]Patty, op. cit., p. 38

[21]William L. Johnson, "Objective Basketball Tests for High School Boys" (unpublished Master's thesis, University of Iowa, Iowa City, 1934), pp. 1-87.

have some merit in shooting ability.[22] The two kinesthetic tests used in this study did not correlate too highly, although the arm raise test did show correlations of .17 at 10 feet and .19 at 21 feet indicating that there may be a slight relationship. The balance stick test showed low negative correlations (-.05, -.14). It is possible that these tests do not measure kinesthesis as it is related to shooting ability.

In summary, it would appear from the results of this study, that the best shooters from 21 feet are those who have quickness in their shooting hand, comparatively weak wrist strength, relatively good flexibility in their wrist, and small hands, which might be regarded as characteristics for guards and possibly the forwards. At closer distances (10 feet) weak but flexible wrists, and larger hands seem to be desirable traits. It is interesting to note that the strength and power measurements used in this study all showed negative correlations with the criterion measurement.

The null hypotheses stated that (1) there is no relationship between jump shooting ability in basketball and selected measurable traits, and (2) a multiple regression equation to significantly predict jump shooting ability in basketball cannot be developed. Both of these hypotheses were rejected because the independent variables showed a significant correlation with jump shooting ability. The computed F ratios for the second equation at 10 feet (182.351 $\gg$ 142.62), the eighth equation

---

[22] Lolas Halverson, "A Comparison of Three Methods of Teaching Motor Skills" (unpublished Master's thesis, University of Wisconsin, Madison, 1949), pp. 1-83.

at 21 feet ($109.976 \geqslant 108.67$) and the second equation for total shots made ($1026.889 \geqslant 344.67$) were above that necessary to be significant at the .05 level of confidence.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the relationship between jump shooting ability in basketball and selected anatomical measurements and motor responses.

Twenty-four varsity and junior varsity basketball players from South Dakota State University (1971-72 season) were the source of the data. They were tested on the independent variables of hand-eye coordination, hand reaction time, speed of movement time, hand size, grip strength, peripheral vision, depth perception, kinesthetic perception, leg power, wrist flexibility, and agility. From the intercorrelations between these independent variables and their correlations with the three dependent variables of the number of shots made at 10 feet, 21 feet, and total shots made, regression equations were developed for the purpose of predicting jump shooting ability.

Conclusions

The results revealed that:

1. The two variables of wrist strength and wrist flexibility related significantly to jump shooting ability at 10 feet.

2. The three variables of wrist strength, hand size, and hand reaction time related significantly to jump shooting ability at 21 feet.

3. The three variables of wrist strength, wrist flexibility, and hand reaction time related significantly to total jump shooting ability.

4. Jump shooting ability at 10 feet can be significantly predicted from a combination of the two independent variables of wrist flexibility and wrist strength.

5. Jump shooting ability at 21 feet can be significantly predicted from a combination of the eight independent variables of hand reaction time, wrist strength, agility, hand size, wrist flexibility, eye-hand coordination, depth perception, and balance.

6. Total jump shooting ability can be significantly predicted from a combination of the two independent variables of wrist strength and eye-hand coordination.

Recommendations

Based on the findings of this study the investigator proposes the following recommendations for further study:

1. That a study be conducted using a similar statistical design and procedure, but using several tests to measure each independent variable.

2. That a study be conducted using a similar statistical design and procedure, but using more subjects with a wider range of basketball ability.

3. That a study be conducted using a similar statistical design and procedure, but using game condition criteria.

BIBLIOGRAPHY

BOOKS

Benington, John and Pete Newell. Basketball Methods. New York: The Ronald Press, 1962.

Clarke, H. Harrison. Application of Measurement to Health and Physical Education. Englewood Cliffs: Prentice-Hall, Inc., 1967.

Cornett, Frederick D., Thomas F. Morrison and Edward J. Tether. Human Physiology. New York: Henry Holt and Company, 1959.

Cousy, Bob. Basketball Concepts and Techniques. Boston: Allyn and Bacon, Inc., 1970.

Cratty, Bryant J. Movement Behavior and Motor Learning. Philadelphia: Lea and Febiger, 1967.

Davis, Elwood C. and John D. Lawther. Successful Teaching in Physical Education. New York: Prentice-Hall, Inc., 1948.

Fox, Edward L. and Donald K. Mathews. The Physiological Basis of Physical Education in Athletics. Philadelphia: W. B. Saunders Company, 1971.

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

Hawley, Gertrude. Kinesiology of Corrective Exercise. Philadelphia: Lea and Febiger, 1937.

Hill, A. V. Muscular Movement in Man. New York: McGraw-Hill Book Company, Inc., 1927.

Jensen, Clayne R. and Gordon W. Schultz. Applied Kinesiology. New York: McGraw-Hill Book Company, 1970.

Johnson, Barry L. and Jack K. Nelson. Practical Measurements in Physical Education. Minneapolis: Burgess Publishing Company, 1970.

Mathews, Donald K. Measurement in Physical Education. Philadelphia: W. B. Saunders Company, 1963.

McCloy, C. H. Tests and Measurements in Health and Physical Education. New York: Harper and Row, 1963.

McCloy, C. H. and Norma D. Young. Tests and Measurements in Health and Physical Education. New York: Appleton-Century-Crofts, Inc., 1954.

Montoye, Henry J. (ed.). An Introduction to Measurement in Physical Education. Indianapolis: Phi Epsilon Kappa Fraternity, Volume 4, 1970.

Oberteuffer, Delbert. Physical Education. New York: Harper and Brothers, 1951.

Ogle, Kenneth N. Researches in Binocular Vision. New York: Hafner Publishing Company, 1964.

Scott, Gladys M. Analysis of Human Motion. New York: F. S. Crofts and Company, 1942.

Sharmin, Bill. Sharmin on Basketball Shooting. Englewood Cliffs: Prentice-Hall, Inc., 1965.

Sherman, Hoyt. Drawing by Seeing. New York: Hinds, Hayden, and Eldridge, 1947.

Wooden, John. Practical Modern Basketball. New York: The Ronald Press Company, 1966.

PERIODICALS

Alderman, Richard B. and Terry Banfield. "Reliability Estimation in the Measurement of Strength," The Research Quarterly, 40:448-454, October, 1969.

Anderson, Teresa W. "Weighted Strength Tests for the Prediction of Athletic Ability in High School Girls," The Research Quarterly, 7:136, March, 1936.

Banister, H. and J. M. Blackburn. "An Eye Factor Affecting Proficiency in Ball Games," The British Journal of Psychology, 21:282-384, 1930.

Barrow, Harold M. "Test of Motor Ability for College Men," The Research Quarterly, 25:250-260, October, 1954.

Beise, Dorothy and Virginia Peasley. "The Relation of Reaction Time, Speed and Agility of Big Muscle Groups to Certain Sports Skills," The Research Quarterly, 8:133-142, March, 1937.

Bennett, C. "Relative Contribution of Modern Dance, Folk Dance, Basketball, and Swimming to Motor Abilities of College Women," The Research Quarterly, 27:253-262, October, 1956.

Benson, Simon. "The Relative Value of Different Forms of Physiotherapy, Especially Diathermy, In Treating Joints Stiffened After Athletic Injuries," The Research Quarterly, 1:57-73, December, 1930.

Bookwalter, Karl W. "Grip Strength Norms for Males," The Research Quarterly, 21:249-253, October, 1950.

Bowers, Louise E. "Investigation of the Relationship of Hand Size and Lower Arm Girths to Hand Grip Strength as Measured by Selected Hand Dynamometers," The Research Quarterly, 32:308-314, October, 1961

Burley, Lloyd R. "A Study of the Reaction Time of Physically Trained Men," The Research Quarterly, 15:232-235, October, 1944.

Burley, Lloyd R. and Roy Anderson. "Relation of Jump and Reach Measures of Power to Intelligence Scores and Athletic Performance," The Research Quarterly, 26:28-34, March, 1955.

Burpee, R. H. and W. Stroll. "Measuring Reaction Time of Athletes," The Research Quarterly, 7:110-118, March, 1936.

Clark, Brant and Neil Warren. "Depth Perception and Interpupillary Distance as Factors in Proficiency in Ball Games," The American Journal of Psychology, 47:485-487, July, 1935.

Clarke, H. Harrison and Donald Glines. "Relationships of Reaction, Movement and Completion Times to Motor, Strength, Anthropometric and Maturity Measures of 13-year-old Boys," The Research Quarterly, 32:194-200, May, 1962.

Cotten, Doyice J. and Lorraine Bonnell. "Investigation of the T-5 Cable Tensiometer Grip Attachment for Measuring Strength of College Women," The Research Quarterly, 40:848-850, December, 1969.

Cotten, Doyice J. and Allen Johnson. "Use of the T-5 Cable Tensiometer Grip Attachment for Measuring Strength of College Men," The Research Quarterly, 41:454-456, October, 1970.

Cumbee, Frances Z. "Factoral Analysis of Motor Coordination," The Research Quarterly, 25:418, December, 1954.

Cureton, Thomas K. "Flexibility as an Aspect of Physical Fitness," Supplement to The Research Quarterly, 12:381-390, May, 1941.

DiGiovanna, Vincent. "The Relation of Selected Structural and Functional Measures to Success in College Athletics," The Research Quarterly, 14:199-215, May, 1943.

Everett, Peter and Frank Sills. "The Relationship of Grip Strength to Stature, Somatotype Components, and Athropometric Measurements of the Hand," The Research Quarterly, 42:241-246, May, 1952.

Gates, Donald D. and R. P. Sheffield. "Tests of Change of Direction as Measurements of Different Kinds of Motor Ability in Boys of the Seventh, Eighth and Ninth Grades," The Research Quarterly, 11: 140-147, October, 1940.

Gray, R. K., K. B. Start and D. J. Glencross. "A Useful Modification of the Vertical Power Jump," The Research Quarterly, 32:230-234, May, 1962.

Graybiel, Ashton. "Russian Studies of Vision in Relation to Physical Activity and Sports," The Research Quarterly, 26:480-485, December, 1955.

Greey, George and Rod Hunsicker. "Studies in Human Strength," The Research Quarterly, 28:111-118, May, 1957.

Harris, Margaret L. "Flexibility," Physical Therapy, 49:591-600, June, 1969.

Henry, Franklin. "The Practice and Fatigue Effects in the Sargent Jump," The Research Quarterly, 13:16-29, March, 1942.

Hilsendager, Donald R., Malcolm H. Strow and Kenneth J. Ackerman. "Comparison of Speed, Strength and Agility Exercises in the Development of Agility," The Research Quarterly, 40:75, March, 1969.

Hinton, Evelyn A. and Lawrence Rarick. "The Correlation of Rogers' Test of Physical Capacity and the Cubberly and Cozens Measurement of Achievement in Basketball," The Research Quarterly, 11:58-65, October, 1940.

Hobson, Robert and M. T. Henderson. "A Preliminary Study of the Visual Field in Athletics," Iowa Academy of Sciences, 48:331-340, 1941.

Hodgkins, Jean. "Reaction Time and Speed of Movement in Males and Females of Various Ages," The Research Quarterly, 34:335-343, October, 1963.

Honzik, C. H. "Role of Kinesthesis in Maze Learning," Science, 22:373, 1936.

Keller, L. B. "The Reaction of Quickness of Bodily Movement to Success in Athletics," The Research Quarterly, 13:146-155, May, 1942.

Knox, Robert D. "Basketball Ability Tests," The Scholastic Coach, 17:45-47, November, 1947.

Kroll, Walter. "Reliability Variations of Strength in Test-Retests Situations." The Research Quarterly, 34:50-55, March, 1963.

Laiding, Lawrence, Richard Monpetit and Henry J. Montoye. "Grip Strength of School Children, Saginaw, Michigan: 1800 and 1964," The Research Quarterly, 38:231-237, May, 1967.

Lautenbach, Ruth and W. W. Tuttle. "The Relationship Between Reflex Time and Running Events in Track," The Research Quarterly, 3:138-143, October, 1932.

Lehsten, Nelson. "A Measure of Basketball Skills for High School Boys," The Physical Educator, 5:103-109, December, 1948.

Leighton, Jack R. "A Simple, Objective and Reliable Measure of Flexibility," The Research Quarterly, 31:205-216, May, 1942.

Low, Frank N. "Some Characteristics of Peripheral Visual Performance," The American Journal of Physiology, 146:573-584, July, 1946.

Martin, Thomas P. and G. Allan Stull. "Effects of Various Knee Angle and Foot Spacing Combinations on Performance in the Vertical Jump," The Research Quarterly, 40:324-330, May, 1967.

McCloy, C. H. "A Preliminary Study of Factors in Motor Educability," The Research Quarterly, 11:28-39, May, 1940.

McCloy, C. H. "Recent Studies in the Sargent Jump," The Research Quarterly, 2:235-242, May, 1932.

Meyers, Carlton R., William Zimmerli, S. David Farr, and Norbert A. Baschnagel. "Effect of Strenuous Physical Activity Upon Reaction Time," The Research Quarterly, 40:332-337, May, 1969.

O'Connell, Eugene R. and William Pierson. "Age, Height, Weight and Grip Strength," The Research Quarterly, 33:442-445, May, 1962.

Olsen, Einar A. "Relationship Between Psychological Capacities and Success in College Athletics," The Research Quarterly, 27:79-89, March, 1956.

Patrick, J. "Quick Reaction Time Means Athletic Ability," The Athletic Journal, 10:68-69, September, 1949.

Phillips, B. E. "Kinesthesis and Its Relation to Learning Motor Skills," The Research Quarterly, 12:571-577, October, 1941.

Rarick, Lawrence. "An Analysis of the Speed Factor in Simple Athletic Activities," The Research Quarterly, 8:89-105, December, 1937.

Roloff, Louise L. "Kinesthesis in Relation to Motor Learning," The Research Quarterly, 24:210-213, May, 1953.

Sargent, L. W. "Some Observations of the Sargent Test of Neuromuscular Efficiency," The American Physical Education Review, 29:47, February, 1924.

Scott, Gladys M. "Measurement of Kinesthesis," The Research Quarterly, 26:324-341, October, 1955.

Seiger, H. W. "Variation in Illumination of the Depth Perception Apparatus," The Journal of Aviation Medicine, 15:401-403, December, 1955.

Sherman, Hoyt. "Aspects of Visual Perception and Their Relationships to Motor Activity," 53rd Annual Proceedings, College Physical Education Association, 53:8, 1959.

Sloan, Louise L. and Adelaide Altman. "Factors Involved in Several Tests of Binocular Depth Perception," The American Medical Association Archives of Ophthamology, 52:524-543, October, 1954.

Smith, Leon E. "Effect of Muscular Strength, Tension, and Relaxation Upon the Reaction Time and Speed of Movement of a Supported Limb," The Research Quarterly, 35:546-553, December, 1964.

Stroup, Francis. "Relationship Between Measurements of Field of Motor Perception and Basketball Ability in College Men," The Research Quarterly, 28:72-75, March, 1957.

Van Dalen, Deobald. "New Studies in the Sargent Jump," The Research Quarterly, 11:113-116, May, 1940.

Westerlund, J. H. and W. W. Tuttle. "Relationship Between Running Events and Reaction Time," The Research Quarterly, 2:95-100, October, 1931.

Winograd, Samuel. "Relationship of Timing and Vision to Baseball Performance," The Research Quarterly, 13:481-493, December, 1942.

Young, Olive G. "A Study of Kinesthesis in Relation to Selected Movements," The Research Quarterly, 16:227-237, May, 1945.

UNPUBLISHED MATERIALS

Barclay, George D. "The Relationship Between Efficient Vision and Certain Sensory Motor Skills." Unpublished Doctoral dissertation, New York University, New York City, 1938.

Cobb, Robert A. "A Comparative Study of Color Recognition in the Peripheral Field of Vision of Participants in Selected Sports." Unpublished Master's thesis, Springfield College, Springfield, 1967.

Cozens, F. W. "The Measurement of General Athletic Ability in College Men." Unpublished Doctoral dissertation, University of Oregon, Eugene, 1928.

Dickson, Joseph F. "The Relationship of Depth Perception to Goal Shooting in Basketball." Unpublished Doctoral dissertation, University of Iowa, Iowa City, 1934.

Erickson, C. E. "A Study to Determine the Relationship Between Certain Psychological Capacities and Success in Coaching Football." Unpublished Doctoral dissertation, Boston University, Boston, 1953.

Fisher, Rosemary. "A Study of Kinesthesis in Selected Motor Movements." Unpublished Master's thesis, Iowa State University, Ames, 1945.

Gallager, James. "A Study of Changes in Eye Movement and Visual Focus During the Learning of Juggling." Unpublished Master's thesis, Pennsylvania State University, University Park, 1961.

Halverson, Lolas. "A Comparison of Three Methods of Teaching Motor Skills." Unpublished Master's thesis, University of Wisconsin, Madison, 1949.

Hermerer, Elsa M. "A Study of the Relationship Between Visual Depth Perception and General Tennis Ability." Unpublished Master's thesis, Unpublished Master's thesis, University of North Carolina, Greensboro, 1968.

Johnson, William L. "Objective Basketball Tests for High School Boys." Unpublished Master's thesis, University of Iowa, Iowa City, 1934.

Mail, Patricia D. "The Influence of Binocular Depth Perception in the Learning of a Motor Skill." Unpublished Master's thesis, Smith College, Northampton, June, 1965.

Patty, Elbert K. "The Relationship of Selected Measurable Traits to Success in Basketball." Unpublished Doctoral dissertation, Indiana University, Bloomington, June, 1953.

Phillips, Bernath. "The Relationship Between Certain Phases of Kinesthesis and Performance During the Early Stages of Acquiring Two Perceptuo-motor Skills." Unpublished Master's thesis, Pennsylvania State College, Philadelphia, 1941.

Roloff, Louise L. "Kinesthesis in Relation to the Learning of Selected Motor Skills." Unpublished Doctoral dissertation, Iowa State University, Ames, 1952.

Ross, Mattie E. "The Relationship of Eye-Hand Coordination Skills and Visual Perception Skills in Children." Unpublished Doctoral dissertation, Ohio State University, Columbus, 1961.

Scolnick, Anthony. "An Electrogoniometric and Cinematographic Analysis of the Arm Action of Expert Basketball Jump Shooters." Unpublished Doctoral dissertation, Springfield College, Springfield, 1967.

Smith, Richard C. "The Effects of Selected Drills Upon the Improvement of Agility." Unpublished Master's thesis, South Dakota State University, Brookings, 1969.

Stevens, Mildred. "The Measurement of Kinesthesis in College Women." Unpublished Doctoral dissertation, University of Iowa, Iowa City, 1954.

Vis, Marlin P. "The Relationship of Forward Pass Catching Ability in Football and Selected Anatomical Measurements and Motor Responses." Unpublished Master's thesis, South Dakota State University, Brookings, 1971.

Wilberg, Robert B. "Hand-Eye Coordination Determined by the Variability in Visual and Motor Responses." Unpublished Master's thesis, University of Oregon, Eugene, 1960.

Zimmerman, Patricia Ann. "The Relationship of Kinesthesis to High and Low Levels of Basketball Ability Among College Women." Unpublished Master's thesis, University of Illinois, Urbana, 1961.

APPENDIX A

TABLE VII

THE RAW DATA, MEANS AND STANDARD DEVIATIONS OF THE THIRTEEN INDEPENDENT AND THREE DEPENDENT VARIABLES FOR THE TWENTY-FOUR SUBJECTS USED IN THE STUDY

Subjects	Depth Perception	Peripheral Vision	Arm Raise	Wrist Flexibility	Hand Reaction	Speed of Movement	Grip Strength	Agility
1	15.0	91.5	10.0	114.0	.169	.223	112.5	12
2	52.5	91.3	4.5	91.7	.170	.217	115.0	14
3	19.5	91.1	13.5	128.3	.167	.220	124.0	9
4	6.4	91.1	13.0	120.0	.170	.210	95.0	11
5	14.8	90.0	17.5	127.0	.172	.237	118.8	12
6	8.3	94.8	22.0	146.7	.157	.239	120.0	12
7	14.1	94.1	20.0	124.0	.161	.202	105.0	10
8	6.5	92.6	9.0	113.3	.154	.202	137.5	12
9	18.1	91.9	17.0	122.3	.182	.234	102.5	11
10	21.9	94.3	12.0	134.3	.144	.194	110.0	14
11	17.7	96.0	6.5	114.3	.168	.210	123.0	13
12	27.4	93.7	11.0	146.0	.161	.204	112.5	13
13	8.8	91.9	8.5	137.3	.165	.228	137.5	12
14	11.3	93.7	7.5	110.3	.167	.235	146.5	8
15	44.4	92.5	14.5	139.0	.153	.235	97.5	14
16	22.1	91.9	4.0	137.3	.169	.245	140.0	13
17	37.3	100.5	8.0	137.7	.177	.239	151.8	14
18	9.4	94.5	3.0	137.3	.175	.249	132.5	13
19	11.6	93.3	14.5	127.3	.137	.200	140.0	12
20	6.2	97.2	12.0	137.3	.173	.233	143.5	13
21	20.1	92.8	4.0	129.0	.150	.213	115.0	13
22	7.1	93.1	5.0	144.5	.170	.217	117.5	15
23	6.5	92.4	6.0	147.3	.174	.239	126.0	13
24	6.5	92.6	9.0	120.0	.178	.231	112.5	15
X	17.3	93.3	10.5	128.6	.165	.223	122.3	12.4
SD	12.4	2.3	5.3	13.7	.011	.016	14.7	1.7

APPENDIX A

TABLE VII (Continued)

Subjects	Hand Size	Balance Stick	Leg Power	Eye-Hand Coordination	Wrist Strength	Shots Made 10 Feet	Shots Made 21 Feet	Total Shots Made
1	26.0	83.8	25.5	16.3	46.7	48	41	89
2	27.4	43.3	24.5	16.3	65.0	43	31	74
3	27.9	35.0	25.0	17.0	48.3	47	37	84
4	27.1	66.7	21.0	15.3	60.0	53	34	87
5	27.3	84.4	26.0	13.0	56.3	51	35	86
6	26.6	49.5	19.5	19.0	63.3	58	44	102
7	26.5	50.4	22.8	16.3	71.7	51	32	83
8	27.5	57.3	22.8	19.5	65.0	51	33	84
9	28.7	52.2	23.0	14.7	41.7	55	30	85
10	27.6	65.9	21.8	18.3	70.0	49	35	84
11	28.4	101.1	27.0	18.0	65.0	51	30	81
12	26.7	72.4	24.3	18.0	72.5	48	29	77
13	28.6	57.7	23.5	17.3	61.7	48	31	79
14	29.5	45.2	23.0	15.7	70.0	38	17	55
15	28.3	43.3	23.0	18.3	35.0	59	45	104
16	28.8	35.4	26.0	18.3	73.3	56	28	84
17	30.1	41.5	32.0	18.3	75.0	52	30	82
18	30.1	117.3	27.5	18.0	63.3	53	27	80
19	28.5	48.5	25.5	17.0	63.3	55	46	101
20	30.2	72.9	26.5	18.3	71.7	61	32	93
21	28.7	47.9	23.8	19.7	43.3	65	51	116
22	26.3	70.3	26.5	20.3	80.0	50	50	100
23	29.7	63.9	28.5	18.7	70.0	53	33	86
24	28.9	69.9	26.0	18.0	90.0	41	21	62
X	28.1	61.5	24.8	17.5	63.1	51.5	34.3	85.8
SD	1.3	20.4	2.7	1.7	15.0	6.1	8.4	13.0