A STUDY OF THE RELATIONSHIP OF SELECTED MEASURES TO TENNIS ABILITY

by

Jean Pankonin

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Director

APPROVAL SHEET

This thesis has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro, Greensboro, North Carolina.

Thesis Director Frank Pleasant

Oral Examination Committee Members

Ethel Martus

Rosemary McGee

Laura G. Anderton

July 14, 1966
Date of Examination

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The purposes of this study were 1) to determine the relationship between related factors of motor ability, including balance, agility, strength, coordination, and height, and the development of tennis ability in women; and 2) to compute the prediction equation for the development of tennis ability using these selected factors.

Thirty-three students, who were freshman and sophomore women from the University of North Carolina at Greensboro, were randomly selected from seven beginning tennis classes. Each subject was given tests which measured agility, balance, hand-eye coordination, grip strength, height, and arm and shoulder girdle strength. This testing was completed in March. At the end of the semester the subjects were evaluated for their tennis ability. This was accomplished by using two objective tests, which have been statistically analyzed, and one subjective measure. The combination of the T-scores of the Dyer Test of Tennis Ability, the Broer-Miller Forehand-Backhand Drive Test, and the subjective skill ratings, which were done by three judges, served as the final criterion of tennis ability.

Intercorrelations for the ten scores were computed on an IBM computer to determine the degree of relationship between the various measures. The Doolittle technique was used to find the combination of tests that would yield the

highest relationship with the criterion. Beta coefficients and prediction constants were found for each of the six independent variables for the formulation of a prediction equation.

The following conclusions were drawn from the results of this study:

1. Agility, balance, and arm and shoulder girdle strength are important elements of tennis ability development.

2. There is no relationship between the criterion and measures of grip strength or hand-eye coordination, as found in this study.

3. The shorter college woman tended to be the better performer in tennis than her taller classmate, although this finding was not significant.

4. The highest multiple correlation found for this tennis criterion was the combination of agility, balance, arm and shoulder girdle strength, height, and grip strength.

5. The most economical combination of elements in this study for the prediction of tennis ability was agility, balance, and arm and shoulder girdle strength with a multiple correlation of .622.

6. The tennis rating form devised for this study was found to have a significant relationship with the Dyer and the Broer-Miller tests of tennis ability.

TABLE OF CONTENTS

CHAPTER		PAGE

LIST OF TABLES

CHAPTER I

INTRODUCTION

Teachers of physical education are often faced with the need to evaluate the abilities of their students and predict their success in tennis or other interscholastic sports. This means, in many instances, that the subject is observed and his potentialities are judged merely on a personal observational basis. Judgments of this type have brought fairly satisfactory results, even though the method is entirely subjective.

The educator, when confronted with the task of choosing team members, may resort to several common methods of selection. He may depend wholly on the results of his experiences with and knowledges of the prospective team member; however, this method has the disadvantage of neglecting the individual who is not as familiar to the instructor. Some teachers focus their attention on the individual's performance on a skill test or on a motor ability battery. This may be a satisfactory way to select members for a team if the main concern is their present level of skill. These individuals, then, are chosen on the basis of their achievement level thus far reached without consideration of their future development.

We in physical education have come to realize that the best all-around athlete is not necessarily the highest skilled player in softball, nor do we think that the best basketball player will necessarily hold the first position on the tennis team. We understand that there are different qualities, or a distinct combination of qualities, which together produce an outstanding performer in a particular sport. Beise and Peaseley (22), in their reaction to motor ability tests, said:

> It is difficult, however, to give practical application of the results of such tests to various sports activities, for with each sport either new elements or differing amounts of the same elements make it necessary to weight differently the component parts of the tests. (22:133)

The body's response to the movement of the ball on the court is quite complex in the game of tennis. It is only natural that some of the components of motor ability are involved to a greater degree than others in the performance of the skills. Some of the game's greatest performers have made statements relating what they felt were the contributing elements that make up the performance of the exceptional player. Mentioned were qualities of motor performance one might include as the basic essentials needed to participate in most any type of game involving a ball.

Winograd (58), in search of a method of choosing the best athletes for a baseball team by use of tests, said:

> It is obvious that a scientific approach might bring greater benefits and perhaps lead to an enhanced efficiency in the selection of candidates and the training of individuals. (58:481)

Because of the apparent interest, willingness, and enthusiasm on the part of women and girls toward increased competition, women physical education teachers, sport club sponsors, and coaches will have more opportunities for selecting individuals to participate as members of a team. Many of the sports offered have numerous students trying out for a starting position. An adequate job of subjectively rating the students may be quite time consuming, inaccurate, and impossible with large groups. Everett (34) points out:

> Few people are aware of the amount of time used by the coach in his effort to obtain a knowledge of the potential abilities of his players. He must have this knowledge in order to select a squad successfully and as a further step, to be able to distinguish accurately the players from the reserves. . . .The number of errors in selection might well be reduced if an objective way of selecting players was available to reinforce his judgment. (34:15)

It may become even more important in the future for women to do a satisfactory job of predicting success in the abilities of their students as their programs for competition expand.

Some of the qualities of motor ability are more important than others as requisites for the development of tennis ability. Therefore, an investigation of the relationship of selected motor ability qualities to tennis skill improvement might furnish information that would be helpful in providing a method for the selection of individuals to a tennis team.

CHAPTER II

STATEMENT OF PROBLEM

The purposes of this study were 1) to determine the relationship between related factors of motor ability, including balance, agility, height, strength, and coordination, and the development of tennis ability in women; and 2) to determine the feasibility of using these related factors to develop a prediction formula for skill attainment of the beginning tennis student at the end of one semester of tennis instruction.

DEFINITION OF TERMS

<u>CRITERION</u>: The score resulting from the combination of T-scores of the Dyer Backboard Test of Tennis Ability, the Broer-Miller Forehand-Backhand Drive Test, and the subjective skill ratings served as the criterion for this study.

<u>RELATED ELEMENTS</u>: Related elements are those elements related to motor ability that were selected for use in this study. There were: strength, agility, balance, hand-eye coordination, and height.

<u>TENNIS ABILITY</u>: As referred to in this study tennis ability is the individual's level of tennis performance as measured

by the Dyer Backboard Test of Tennis Ability, the Broer-Miller Forehand-Backhand Drive Test, and the subjective skill ratings.

LIMITATIONS

The limitations in this study were the following:

1. The time schedule for testing could not be randomly controlled due to the inconvenience it placed on the subjects and the test administrator.

2. No care was taken to determine the degree to which the subject qualified as a beginning tennis player.

3. Due to the inadequate facilities for the testing of the subjects at this time in the semester, only those tests which could be adequately performed in the room available and yet provide the opportunity to measure those qualities desired were selected.

4. Because of the very poor weather conditions the subjects had unequal opportunities to perform well on the skill testing and the tennis ratings.

5. One of the three sets of skill ratings was done by six different tennis teachers.

CHAPTER III

REVIEW OF LITERATURE

This study was primarily concerned with the relationship of various elements of motor ability to tennis performance. Five elements of performance were chosen on the basis of being essential qualities found in general motor ability; one measurement, that of height, was included as it seemed to present a logical and important measurement when considering the basic principles of tennis.

MOTOR ABILITY

Motor ability has been analyzed for its component parts. Various sources have discussed the elements that make up this general term of motor ability.

Humiston (40), in her study involving the motor ability measurement in women, listed running, dodging, jumping, getting up from the floor (equilibrium), and hand-eye coordination as the fundamental elements of motor activity as analyzed by experts.

Strength, velocity, muscular coordination, body size, height, weight, motor educability, balance, agility, force, and endurance appeared as important factors when Mathews (9) reviewed factor analysis studies of motor ability.

Alden, Horton, and Caldwell (15) stated that general motor ability, as viewed by physical education judges, was composed of the following elements: speed, arm and shoulder strength, endurance, strength of legs, balance, arm and shoulder coordination, accuracy, agility, flexibility, abdominal strength, and rhythm.

According to Barrow and McGee (1), motor ability is made up of the following factors: Speed, strength, power, endurance, agility, balance, flexibility, coordination, kinesthetic sense, hand-eye-foot-eye coordination, and motor educability. Barrow and McGee state that:

> Motor ability is made up of factors which are basic to all movement. . . .These factors are indicative of abilities which underlie, or which form the basis for movement and are causal to both fundamental body movements such as running, jumping, and throwing, and specific skills as applied to sports. (1:122)

Kammeyer (41) stated that an individual proficient in a variety of athletic skills will also possess a high degree of general motor ability.

BALANCE

Balance, though not usually thought of as being one of the most important factors in performance, is necessary for the proper coordination of movement. Driver (5) discussed the importance of balance for good form in the tennis strokes. Distinguished for her tennis ability, Wightman, as noted by Driver, emphasized body balance when working with girls.

Cooke (4:78) stated: "Besides relaxation, there's nothing more important to your tennis than balance and rhythm."

Static balance was found to be an important factor in dynamic balance when analyzed factorially. According to Bass (18), ". . .static balance would appear as a part of the dynamic balance which appears as an important factor in the general motor and rhythm skills as rated." When correlated (18:42) with general motor ability scores, static balance has a coefficient of .4157. Although dynamic balance is considerably higher when measured with this criteria than static balance, this coefficient of .4157 is high enough to suggest its importance in the criteria used.

Slater-Hammel (53) investigated the differences in ability of athletes and non-athletes to balance on the Reynold's Balance Test. Three groups, varsity athletes, physical education majors, and liberal arts majors, were measured on this test which involved balancing on a teeter-board. The participant was to move his body on this apparatus so as to light a white light which corresponded to a previously activated red light, of which there were five, immediately above it. The author found, as a result of this study, that the varsity athletes and physical education majors were significantly better in their ability to balance than the liberal arts majors, and that the varsity athletes were significantly better in their balance performance than the physical education majors.

The relationship between static equilibrium and ability in gross motor activities was investigated by Estep (33). Her subjects were chosen on the basis of subjective ratings of motor ability in sports and rhythms and team skill classification in the after school program. Miles ataxiameter was used to measure anterior-posterior and lateral sway. The results supported the hypothesis that there is a positive and significant relationship between static equilibrium and ability in gross motor activities.

A study involving the relationship between dynamic balance and ability in swimming was done by Gross and Thompson (37). Seventy-eight experienced swimmers were rated by experts for swimming ability on nine strokes, were timed three times on the 30 yard sprint, and took the Bass Test of Dynamic Balance. It was found that the subjects who possessed more swimming ability tended to have better balance ($r = .65$) while those who could swim faster had the better dynamic balance ($r = -.75$). Both coefficients were significant at the one per cent level of confidence.

Mumby (49) worked with twenty-one subjects who were chosen from the intermediate or advanced wrestling groups. Two judges evaluated each subject's ability to handle himself in wrestling. Each was given a balance test. The performance was measured by a stabilometer. It was concluded that good wrestlers are better in balancing than poor wrestlers. However, the correlation between the judges' ratings of wrestling ability and balance are not significant.

In attempting to establish a set of tests for the measurement of kinesthesis, Roloff (52) tested twenty-two tennis students among others on eight tests, including tests of balance, and measured subjects for motor ability by using

Scott's test of motor ability. Scott's test, when correlated with the subjects' tennis performance scores, yielded a significant coefficient of .44. When tennis performance was correlated with these tests of kinesthesis, no significant correlation could be found.

Espenschade, Dable, and Schoendube (31) measured 287 subjects on their ability to maintain balance on Seashore's beam walking test. These 287 scores were correlated with the subjects' assigned grades in physical education. The coefficient of correlation was $.62 \pm .03$. Ten boys from this group were selected by their physical education instructors on the basis of their outstanding athletic ability while ten were selected because of their lack of athletic ability. The respective balance scores were 56.7 and 49.1. The authors concluded that: "The relationship between dynamic balance and physical abilities appears to be substantial." (31:274)

AGILITY

Agility is the ability to move the body quickly and with ease from one place to another. Barrow and McGee (1:118) state that agility: ". . .is revealed to a great extent in sports involving efficient footwork and quick changes in body position."

In addition, Murphy and Murphy (11) believe footwork is learned through sports participation and contributes significantly to the development of timing. Footwork is of utmost importance for success in the majority of sports as emphasized by Trengove (14). More specifically, Honda (59) feels that good footwork is most essential in producing a good shot in tennis.

Mohr and Haverstick (48) conducted a study to determine the relationship between height, agility, and jumping ability to volleyball skill. The repeated volleys test was performed at the three-foot and seven-foot distances for the criteria scores. Agility was measured by Scott's Motor Ability obstacle race. One hundred and two women enrolled in an eight-week college volleyball course were tested and measured for height. The results of the testing showed a significant relationship between agility and the repeated volleys test at both distances and a significant relationship between height and the volleying test when performed at the three-foot restraining line; however, the relationship between these two factors was not significant when the volleying test was performed at the seven-foot distance.

Lafuze (44) selected two groups of subjects which were selected on the basis of their motor ability T-score as established by the Scott Test. Those scoring high on this test comprised one group numbering 84, while the low achievers, forming the other group, numbered 89. These two groups were given tests in various aspects of motor ability and involved items of dynamic balance, kinesthesis, serial reaction time, agility, and strength of arm and shoulder girdle as measured by the push-pull dynamometer attachment. This study indicated, at the one per cent level of confidence, that these two groups differed in their ability to perform the tests of agility, balance, reaction time, and strength.

A study investigating the relationship between change of direction skill to agility and to games ability was done by Gates and Sheffield (36). One hundred and sixty 7th, 8th, and 9th graders were tested on eighteen measures; fifteen of which were tests for change of direction and three were for the measurement of motor ability. All change of direction scores were determined by judgment of good, fair, and poor. This was established before the change of direction tests were given to the subjects. The tri-serial correlation of the total T-score and agility yielded a .8618 coefficient while a .8034 was found for the correlation of total T-score and games ability. It is apparent that change of direction is an important factor in agility as determined by this study.

Wettstone (57) did a preliminary study of the essential qualities of a gymnast as rated by outstanding coaches and gymnasts. Using the results of this investigation he tested and measured twenty-two subjects who ranged from inexperienced to varsity team members. Tests included agility, strength, kinesthesis, timing, flexibility, physical courage, and others. Eleven anthropometrical measurements were taken, including a height measurement. After seven months of observation, the gymnastic coaches subjectively rated each subject in relation to his gymnastic skill. When correlated with the coaches' ratings, a multiple correlation of .79 was found for the Burpee test, height, strength, and thigh circumference. A prediction formula was constructed consisting of these elements.

Beise and Peaseley (22) studied the relation of speed, agility, and reaction time of big muscle groups to certain sports skills. Three groups were formed; one was composed of those who were skilled in the sports area; another group was composed of those who showed an inability in physical education activities; and the last group was selected for either the highness or lowness of their score on the first set of the Brace Motor Ability Tests. The test required the subject to respond to a light by moving off one floor plate and running to the second for the reaction and speed scores. From this second floor plate the subject, on the light signal, ran through a series of stools and back to the first floor plate for the agility score. A timing device was attached to each floor plate. The same type thing was done with arm movements by alternately pushing down and lifting up on these plates. The authors found that the skilled players of golf, tennis, and archery had significantly better scores than the two unskilled groups in reaction time, agility, and speed. Interestingly enough, tennis, a sport which by its very nature demands rapid coordination of the body, demonstrated faster speed, reaction time, and agility than the other two sports of golf and archery.

DiGiovanna (29) investigated the relationship of various functional and structural measures to success in several sports including tennis. He measured 836 subjects, including 102 athletes, for power, strength, height, weight, etc. From this information he found only two measurements that distinguished the tennis players from the normal group. Tennis players had longer legs ($r = .42$) and weaker left grips ($r = +.37$), both of which were significant coefficients. This implies that power, strength, etc., contribute very little to the success of this sport group. The author suggested that factors not measured in this study, such as agility and stroke technique, may be important elements in college tennis.

STRENGTH

The importance of possessing a minimum of strength is recognized necessary for all sports, whether it be wrist strength for badminton, total strength for wrestling, or leg strength for running. Strength is needed for muscular movement. In relation to tennis, Driver (5:38) stated: "Beginning girl pupils must develop strength in the shoulder girdle and arm muscles in order to swing the racquet freely in the drives."

Lamp (45) measured height, weight, and grip strength of 429 girls and 377 boys in the 7th, 8th, and 9th grades. Four volleyball skill tests, the serve, set-up, volley, and net-pass, were given. She found that height had the highest relationship to the volleying test, and, although low, strength had a positive relationship to the volleyball skills.

A study was made by Burkirk, Anderson, and Brozek (26) in which various anthropometric measures of the forearm and hand were taken. The subjects were eleven soldiers and seven nationally ranked tennis players. Significant differences were found between the dominant arm and the other arm of the tennis players. Other significant findings were: "Muscle diameter measured at mid-ulna and grip strength differed between arms in both groups but the differences were larger in the tennis player." (26:131)

Wessel and Nelson (56) selected a random sample of college women and measured the grip strength of each. Other information was secured for these subjects. When grip strength scores were correlated with weight, a significant coefficient of .371 was found; when correlated with height, the significant coefficient was .222. The grades received by the subject in her previous physical education classes were compared to her grip strength score and a significant relationship resulted, indicating that achievement in physical education (as measured by grades) was related to strength as found for these college women.

Tinkle and Montoye (54) conducted the same study on 635 freshman and sophomore college men. The relationship between grip strength and achievement in physical education, as measured by grades, was found to be significant and positive.

Owens (50), in response to Tinkle and Montoye's study reported a very low, but positive relationship (.186) between grip strength and physical education grades when testing seventy-one freshmen at the U.S.A.F. Academy. Two sections from swimming, wrestling, boxing, and gymnastics were randomly selected for this study.

Ninety varsity wrestlers were classified as successful or unsuccessful as determined by winning first or second place in the sectional tournament or by placing in the state meet. All subjects were tested on response time and four measures of strength, including right and left grip, back lift, and leg lift. Kroll (43) found that the successful wrestlers had significantly greater mean strength scores of the right and left grips and the back lift than did the unsuccessful wrestlers.

Hinton and Rarick (38) gave sixty-four women two tests. They were Rogers' Test of Physical Capacity, which is made primarily of strength events, and the Cubberley and Cozens Basketball Achievement Test. A correlation of .809 was found after correcting for attenuation for these two tests. The highest correlation between any two variables was .550; this was the coefficient found for basketball achievement and arm strength.

The same strength test, the Rogers' Test of Physical Capacity, was used with some modification by Anderson (16). Three hundred high school girls in the sophomore and junior classes were tested on Rogers' test and the 40-yard dash, standing broad jump, running high jump, and the basketball throw. These four measures were used as an indication of the girl's athletic ability. A multiple correlation of .55 was found with the strength tests and athletic ability. The author concluded that: "Strength as tested by this test or other strength tests in use is not the sole factor in the athletic ability of girls." (16:142)

Carpenter (27) gave tests of strength and power to each of her 100 subjects. Track and field events were scored for each as a measure of their athletic performance. A definite positive relationship (.3959) was found between strength and athletic performance. The investigator suggested that stronger individuals are superior in athletic performance as measured by the track and field scores than individuals with less strength.

Fifty-six freshman men from physical education class were measured on eight structural factors and eleven strength measures in the study by Hook (39). Each was measured on his ability to hit, run, throw, and field in baseball. A combination of these four skills made the score for total baseball ability. The strength and structural scores were correlated with the criterion. Left shoulder flexion yielded the highest significant correlation (.67) with the criterion of total ability; right shoulder flexion was next with a significant .55. Structual factors had low correlations with the criterion.

McCloy (47) reviewed eight different studies involving the Rogers' Test of Physical Capacity with various criterion. The results, in each case, were essentially the same with the outcome favoring the fact that arm and shoulder girdle strength is of great importance in motor activities. McCloy suggested that arm and shoulder girdle strength may be of even greater importance than back and leg strength for general motor performance.

HAND-EYE COORDINATION

Much has been said about hand-eye coordination and its importance to performance; however, little research could be located in its relationship to sports. This quality may be found in several forms according to McCloy (10:154):

> (1) moving the whole body to meet a ball flying through the air. . . .
> (2) imposing the hand or foot in the path of the rapidly moving object. . . .
> (3) throwing or kicking an object accurately in order that it may strike a distant target. . . .

Barrow and McGee (1) stated that hand-eye coordination is usually referred to as "keeping your eye on the ball". Bruce and Bruce (3), Browne (2), Driver (6), Murphy and Murphy (11), and Edgren and Robinson (7) emphasized the importance of "keeping one's eye on the ball" in tennis.

Honda (59) stated that: "Development of the big muscles, stamina, and eye-hand coordination are necessary for playing a good game of tennis." (59:1)

Martus (46) did a study involving coordination. The egg race, hip lift, backward jump, and the Miles pursuit pendulum were the four tests used in this study. Care was taken by the author to select tests that eliminated, as much as possible, elements of balance, endurance, reaction time, and strength. One hundred freshmen took these tests and these scores were correlated with those made on the Lensch Motor Ability Test. Coefficients ranged from .371 for the backward jump to .487 for the egg race. When correlated with the Lensch Motor Ability scores and an endurance run, the hip lift and egg race had a coefficient of .623.

Everett (34), in an attempt to predict baseball ability, tested thirty varsity baseball players on various elements. He included Thurstone's "S" test to measure the ability to visualize spatial relationships. The subject's playing ability was rated and used as the final criterion. The results of this study showed a high negative correlation between the "S" test and the criterion. The Sargent Jump was found to be the best single measure for predicting baseball ability.

Bates, as reported by Everett (34), did a study in which hand-eye coordination and batting averages of high school baseball players revealed a correlation of .81.

Beall (19, 20, and 21) did a study in which she investigated the essential qualities necessary to become a good tennis player. Several leading tennis authorities were consulted and they suggested that aggressiveness, agility, concentration, muscular coordination, endurance, flexibility, health, modesty, speed, and others were important qualities necessary for the development of a good tennis player. Beall (19 and 20) gave tests of agility and coordination, among others, to her subjects at the beginning and again at the end of their eight-week tennis course. It was found that there was very little improvement in coordination and agility as a result of this instruction and practice. This was attributed to the short time the subjects had for improving their tennis ability. Beall (21) concluded that coordination: ". . .used in the strokes of tennis is probably specific and not general as shown by a lack of correlation between the general coordination test and the forehand drive." (21:648)

HEIGHT

Recognized as an important characteristic in a basketball player, height may be valuable in other sports as well. Certainly a taller tennis player has the advantage when serving and smashing, not to mention his longer levers, the arms, for added power. McCloy (10) stated that height may have some influence in motor activity due to the accompaniment of weight and age.

Watson (55) gave a throwing for distance test and a throwing accuracy test to each of 477 women. Measurements of the upper body were taken including height, shoulder width, chest depth, etc. The correlation found for distance and accuracy was .7560 with a P.E. of .0132. The relationship between the college woman's body measurements and her ability to throw accurately or to throw for distance was very low.

In a study by Cozens (28), 3,965 entering college freshmen were used as subjects. The middle 50 per cent in height measurement comprised one group, and the upper 25 and the lower 25 per cent composed the other two groups. Each of these groups was divided into slender, medium, and heavy builds. Every individual was tested on seven events of athletic ability: baseball throw, football punt, dive for distance, standing broad jump, dip on the parallel bars, dodging, and the quarter mile run. Cozens found that, as a group, tall men are superior in these athletic events than those who are short. He said: "Even with college men, we must recognize the superiority of certain stature groups over others. . . .it has been shown quite definitely that short men and slender men are materially inferior in performance ability." (28:43)

Krakower (42) investigated the skeletal differences between a non-track group and a track group in performing the running high jump. Sixteen men who had specific track training were compared with 561 untrained men. Various skeletal measures were taken and their ability to perform the running high jump was recorded for all. The author first compared the highest jumpers of the non-track group with those who were in the lowest percentile of the same group. It was evident that the higher jumpers had longer legs, broader feet, and were taller. When comparing these higher jumpers of the non-track group to those in the track group, he found the same to be true, the greater length of leg, the broader foot, and the greater height, in favor of the track group.

Pierson (51) found no significant differences in the height of fencers and non-fencers.

Bemies (23) measured 2,300 students between the ages of 16 and 27 years of age on 43 different measurements of the body. Averages for these measurements were computed. Five track men, who were first place winners in eight events in an intercollegiate tournament, were also measured. Bemies reported that the average height of these five track subjects were two inches higher than the average student's height, with only 20 per cent of the average students being as tall.

Baacke (17) tested eighty-seven subjects on the standing hop, step, and jump, running and standing broad jump, 50 yard dash, leg lift, balance beam measure, Scott's obstacle race, sit and reach, and three anthropometric measures. The criterion was the running hop, step, and jump. The investigator wished to find the relationship of physical performance and the anthropometric measures to ability to perform the running hop, step, and jump. All variables were found to have a significant relationship with the running hop, step, and jump; the highest single correlation was the standing hop, step, and jump ($r = .861$).

Results of children taking the California Physical Performance Test were restudied by Espenschade (32). She concluded that:

> Correlations of performances in five tests events with height and weight at each age 10 to 18 for boys and 10 to 7 for girls are low and in many instances are not significant statistically. (32:152)

This was found to be true for a sample of athletes as well.

Breitinger (24) did a study in Munich, Germany, involving body measurements and athletic achievement. Two thousand three hundred participated in the achievement tests of the 60-meter sprint, standing broad jump, running high jump, putting a medicine ball, and a baseball throw for distance. Body measurements, including height, were recorded. The study indicated that during adolescence, the taller individual has the advantage in speed and that there was a moderate correlation between height and the jump between the ages of 12 and 18.

CHAPTER IV

PROCEDURE

This study was concerned with predicting tennis ability by means of related elements of motor ability, which were logically assumed to enter into the execution of the skills of tennis. Tests measuring balance, shoulder girdle and arm strength, height, agility, coordination, and grip strength were administered to each of the subjects. The final criterion was the combination of three measures of tennis ability.

SELECTION OF SUBJECTS

Seven classes of beginning tennis were offered at the University of North Carolina at Greensboro in the spring semester of the 1965-66 school year. The classes, which met twice a week for the semester, were taught by six different instructors, one of whom taught two classes of beginning tennis. Each of the instructors was asked if members of his class or classes could be used in this study. Each was requested to submit a class list of students and was asked if he would, as the subject's instructor, rate these subjects on their ability to play tennis at the end of the semester. During this brief meeting the study was explained and questions were answered. All agreed to allow their students to participate in this study if they so chose and all instructors offered their cooperation to help rate students at the end of the semester.

The students were listed in alphabetical order according to class and the classes were arranged in proper sequence. A number was assigned to each student. A random sample of thirty-five subjects was selected from 192 students enrolled in the seven beginning tennis courses. The sample was supplied with the aid of a table of random numbers (12).

Of the thirty-five subjects, all were right-handed women of freshman or sophomore standing at the University. No care was exercised to screen the subjects selected to determine the degree to which they qualified as beginning tennis players.

Each student randomly selected was contacted personally via her tennis class by the writer and was acquainted briefly with the study; its purposes and factual information concerning the testing program were also discussed. All girls who were asked to participate in this study agreed to serve as subjects.

The subjects were contacted by note, which was delivered to their dormitories, to schedule them for the related elements testing for this study. Subjects were not contacted for the criteria data as the test administrator was able to test, with the approval of the class instructors, during the class periods. The skill ratings were done at the convenience of the individual rater within a specified time interval.

During the course of the semester, two subjects had to be dropped from the study; one was due to prolonged illness and the other, to a leg injury.

SELECTION OF MEASURING INSTRUMENTS

The qualities of motor ability which were believed to enter into tennis performance included the following: balance, agility, arm and shoulder strength, height, grip strength, and hand-eye coordination. Established tests were used to measure these qualities.

The tests used to measure tennis ability were chosen with concern for their reliability and validity. This was taken into consideration as well as their ease of administration and the test's objectivity.

Scott's Motor Ability Test (13), which included the basketball throw for distance, made available a score for arm and shoulder girdle strength. The best throw out of three was recorded when students took this battery in the fall of their freshman year. The reliability for the basketball throw was .89 based on successive trials for 200 women. The validity was .79 when correlated with a longer but similar test; when correlated with McCloy's total points score, the coefficient was .78.

The target test by Garfiel (35) supplied the evaluation tool for the hand-eye coordination element. It consisted of four concentric circles, the smallest being one inch in diameter; the largest was thirty inches in diameter. Each circle had a point value. The subject's score was the total number of points made in five throws from behind a line twelve feet from the target.

A grip strength measurement was taken for each subject. The instrument, a grip dynamometer (rectangular type), was calibrated previous to the testing. The subject's score was the number of units shown by the indicator on the instrument. The distance the indicator moved was determined by the amount of pressure exerted on the level grips of the device.

The agility element was evaluated through use of the North Carolina Fitness Test (1). Agility, along with the other items in the total test, was chosen by a jury on the basis of information rendered by a fitness committee. The subject was to move between two parallel lines eight feet apart using a side-step pattern. The score was the number of times the lines were reached by the participant in thirty seconds.

Each subject was measured for height on a Detecto-Medic Scale. The subjects were measured to the nearest quarter of an inch; all were in stocking-feet.

The static balance test used in this study was originally designed by Bass. McCloy (10), perhaps in an attempt to make it easier to administer, adapted it by eliminating one section of the original test which compelled the subject to perform the test with his eyes closed. McCloy tested individuals on his adaptation and found the coefficient to be .8 to .9 for reliability. It had a .5 when correlated with general motor ability of women. For practical purposes, the test was adjusted for this study to include half the number of trials found in McCloy's test. The subject had to maintain his balance while supporting his weight over a stick one inch square and twelve inches long. Time was recorded when any part of the body touched the floor up to sixty seconds. This had to be done in each of two different positions, one in which the length of the foot was in contact with the wooden piece, and the other when only the width of the foot was contacting the wood.

Because of the controversy among teachers of tennis concerning the Dyer Backboard Test of Tennis Ability for beginners, two objective tests were chosen for the measurement of tennis ability. Dyer's (30) reliability of .70 on the test-retest with six intervening weeks of practice and the validity of .92 as measured against a round robin tournament would indicate that it is an excellent measure for evaluating this type of ability. The revision of Dyer's original test, in which the participant was to volley a ball against a flat wall surface from behind a five-foot restraining line, was used. The number of times the subject rallied the ball against the backboard above a line three feet from the floor in thirty seconds was recorded. The final score was the total of three thirty second trials.

The Broer-Miller Forehand-Backhand Drive Test (25) was used as the second objective device for the evaluation of tennis ability. The reliability for beginners and intermediates was .80, while the validity, as measured against judges' ratings, was .85 for the intermediates and .61 for beginners. The participant was instructed to stand behind the baseline, bounce the ball to herself, and, using the forehand or backhand arm movement, stroke the ball into the deep portion of her opponent's court. The court was divided into seven areas, each of which was bounded by the two sidelines. The areas were given values. Fourteen forehand and fourteen backhand trials were given to each subject. Final score was the total of all twenty-eight balls hit. Full value was given for a ball landing in the area if the ball passed between the net and rope, which was four feet above net level; half credit was given for a ball landing in an area if it passed over the rope.

The last measurement used to evaluate tennis ability was a skill rating. All subjects were rated by three individual raters during their tennis class while practicing with a partner or while engaging in a game situation. For this study, a tennis skill rating form (see Appendix) had to be constructed due to the lack of a rating scale of this type. It was made so that it could be applied to a beginning tennis player. This scale did not take into consideration the measurement of form, as the subjects were instructed by different teachers and it was thought that there may have been some variation in the teaching of form.

ADMINISTRATION OF TESTS

Each subject was asked to report at a specified time to the testing station. She was instructed to wear clothing that allowed complete freedom of movement and gym shoes. The testing of related elements was completed in the month of March. This testing was performed in the late mornings or early afternoons. All tests were adequately explained and the more difficult ones also demonstrated. The tests used were administered in the following order: grip strength, accuracy throw, balance, agility, and height measurement. Approximately ten minutes were spent for the explanation and administration of the tests for each girl. The arm and shoulder strength score, as measured by the basketball throw, was obtained from the Scott Motor Ability Test, which was performed at the beginning of their freshman year. All tests, with the exception of the basketball throw, were given by the test administrator, within a period of ten days and all scores were recorded on the individual score cards, a copy of which can be found in the Appendix.

Two of the final measurements of tennis ability, the Broer-Miller and Dyer tests, were administered during the first ten days in May. Testing was done in the tennis classes by the test administrator and the results were recorded on the individual score cards. Approximately four subjects were measured on these tests during a class period of forty minutes. Time included a relatively long walk from the tennis courts for the Broer-Miller test to Coleman Gymnasium for the Dyer Backboard test.

Each instructor, who was previously asked to rate his randomly selected students, was given copies of the rating form and a letter explaining the important points to remember when using this rating device. A copy of the letter and the tennis rating form can be found in the Appendix.

Each subject was rated according to her tennis ability by three raters. One was the subject's instructor and the other two raters were graduate students who had taught and coached tennis. The scores were tabulated on the rating form and were later combined into one score for each subject. The ratings were done during the class period by observing the subjects playing in a non-tournament game or practicing with partners on their own. Each instructor allowed play to be regulated by raters if more information was needed on backhand, serve, etc. The individual instructor was asked to rate his students within a particular week; the same week the two independent raters were to rate. This could not be strictly adhered to due to the very poor weather conditions.

TREATMENT OF DATA

Each subject had a series of ten scores which were the results of various tests. Six of these represented scores made on the related elements of motor ability testing; three represented scores made on the skill rating and the two tennis ability tests; and the last score was a combination of the three means of evaluating tennis ability. Each of these three scores, the Dyer Backboard, the Broer-Miller, and the skill rating, was converted to a T-score and then added together to produce the final criterion of tennis ability.

The ten test scores of the thirty-three subjects were intercorrelated to find the relationship between each other, noting especially the association between the related skills to those scores representing tennis ability. Multiple correlations also were computed to find a combination of the six related skills tests that would produce the highest relationship to the tennis ability score. Lastly, a regression equation was computed, allowing the proper weighting of the related elements of motor ability, to predict tennis ability.

CHAPTER V

PRESENTATION AND INTERPRETATION OF DATA

The purpose of this study was to find the relationship between various measures of motor performance to tennis ability development in women.

The total number of test scores for each individual was ten. Six of these were scores made on the related elements tests. Three were the measures of tennis ability, the Dyer, Broer-Miller, and the skill ratings. The last score was the criterion, which was a combination of the three T-scores made on the tests of tennis ability.

Intercorrelations for the ten scores were computed on an IBM computer using the SPS 1620/1710 program to determine the degree of relationship between the various measures. These correlations are shown in Table I, page 34. Also furnished were the sums, means, and standard deviations of these scores, which can be found in the Appendix.

Correlations significant at the five per cent level of confidence numbered six. Ten coefficients were found significant at the one per cent level of confidence. When the tests of tennis ability were correlated with one another and with the final criterion, six of the ten correlations found significant at the one per cent level were provided.

TABLE I

INTERCORRELATION COEFFICIENTS

N 33

	1	2	3	4	5	6	7	8	9	10
1. ACCURACY		-.046	.125	.193	.059	-.280	-.083	.152	.056	.048
2. AGILITY			.374*	.570**	-.117	.147	.430*	.318	.310	.412*
3. BALANCE				.321	-.322	-.289	.335	.470**	.317	.432*
4. B.B. THROW					.126	-.065	.478**	.364*	.429*	.492**
5. GRIP STRENGTH						.010	-.029	.006	.051	.012
6. HEIGHT							-.307	-.274	-.040	-.237
7. BROER-MILLER								.633**	.598**	.863**
8. DYER									.606**	.866**
9. SKILL RATING										.854**
10. TOTAL CRITERION										

*Significant at the five per cent level of confidence
**Significant at the one per cent level of confidence

The tests that were significant at the five per cent level were as follows: agility with the Broer-Miller test, with the criterion, and with balance; balance with the criterion; and the basketball throw (strength) with Dyer's test and with the skill ratings. Those significant at the one per cent level were: agility with the basketball throw, balance with Dyer's test, basketball throw with the Broer-Miller test and with the criterion, and the intercorrelations between the tennis ability tests and the criterion.

It was interesting to observe the relationships found between the related qualities and the final criterion. Agility, balance, and the basketball throw correlated significantly with tennis ability. Very little relationship was apparent for the accuracy throw (hand-eye coordination) or the grip strength scores. A negative coefficient between height and tennis ability was found.

In order to find the combination of these tests that would yield the highest relationship with the criterion, multiple correlations were computed using the Doolittle technique. The results of this computation can be found in Tables IIA and IIB, pages 36 and 37. A table of coefficients of correlation and t-ratios for varying degrees of freedom and number of variables (8) was consulted to determine the levels of significance for each of the multiple correlations. The number of coefficients that were found significant at the five per cent level of confidence for two, three, four, five,

TABLE IIA

MULTIPLE CORRELATION COEFFICIENTS

From Two Variables	From Three Variables
$R_{0.12}$ = .251	$R_{0.123}$ = .422
$R_{0.13}$ = .332	$R_{0.124}$ = .473*
$R_{0.14}$ = .395	$R_{0.125}$ = .254
$R_{0.15}$ = -.057	$R_{0.126}$ = .331
$R_{0.16}$ = .204	$R_{0.134}$ = .521*
$R_{0.23}$ = .428*	$R_{0.135}$ = .335
$R_{0.24}$ = .478*	$R_{0.136}$ = .396
$R_{0.25}$ = .264	$R_{0.145}$ = .397
$R_{0.26}$ = .338	$R_{0.146}$ = .450
$R_{0.34}$ = .526**	$R_{0.156}$ = .208
$R_{0.35}$ = .342	$R_{0.234}$ = .622**
$R_{0.36}$ = .402	$R_{0.235}$ = .430
$R_{0.45}$ = .403	$R_{0.236}$ = .479*
$R_{0.46}$ = .455*	$R_{0.245}$ = .480*
$R_{0.56}$ = .219	$R_{0.246}$ = .525*
	$R_{0.256}$ = .341
	$R_{0.345}$ = .527*
	$R_{0.346}$ = .568**
	$R_{0.356}$ = .404
	$R_{0.456}$ = .457

*Significant at the five per cent level of confidence
**Significant at the one per cent level of confidence

0 Criterion
1 Accuracy Throw
2 Agility
3 Balance
4 Arm and Shoulder Strength
5 Grip Strength
6 Height

TABLE IIB

MULTIPLE CORRELATION COEFFICIENTS

From Four Variables	From Five Variables	From Six Variables
$R_{0.1234}$ = .582*	$R_{0.12345}$ = .584*	$R_{0.123456}$ = .622*
$R_{0.1235}$ = .424	$R_{0.12346}$ = .621**	
$R_{0.1236}$ = .474	$R_{0.12356}$ = .476	
$R_{0.1245}$ = .475	$R_{0.12456}$ = .522	
$R_{0.1246}$ = .520*	$R_{0.13456}$ = .556*	
$R_{0.1256}$ = .333	$R_{0.23456}$ = .626**	
$R_{0.1345}$ = .523*		
$R_{0.1346}$ = .564*		
$R_{0.1356}$ = .398		
$R_{0.1456}$ = .452		
$R_{0.2345}$ = .588**		
$R_{0.2346}$ = .625**		
$R_{0.2356}$ = .481		
$R_{0.2456}$ = .526*		
$R_{0.3456}$ = .570*		

* Significant at the five per cent level of confidence
** Significant at the one per cent level of confidence

0 Criterion
1 Accuracy Throw
2 Agility
3 Balance
4 Arm and Shoulder Strength
5 Grip Strength
6 Height

and six variables were three, six, six, two, and one, respectively, when correlated with the criterion. Those that were significant at the one per cent level were one coefficient when correlating with two variables, two with three variables, two with four variables, and two with five variables.

The highest multiple correlation coefficient yielded when using two independent variables of balance and arm and shoulder strength with the criterion was .526, which is significant at the one per cent level. A coefficient of .622 at the one per cent level of confidence was found for agility, balance, and the basketball throw (arm and shoulder strength). The correlation with the four variables of agility, balance, basketball throw, and height yielded a .625. The highest multiple correlation, .626, resulted with the elements of balance, agility, the basketball throw, grip strength, and height. With the inclusion of the hand-eye coordination factor for a multiple correlation of all six variables with the criterion, the coefficient dropped to a .622.

Beta coefficients were computed in order to obtain the prediction coefficient constants necessary for the formulation of a prediction equation. The prediction constants were found for each of the six variables and are reported in Table III, in the Appendix.

Since the best multiple correlation coefficient found was rather low for the prediction purposes, it was thought that one prediction equation involving three variables would be sufficient insofar as there was only .004 difference between it and the highest multiple coefficient, which involved five variables. The prediction equation for tennis ability is as follows:

$$X_0 = 1.192(X_2) + .096(X_3) + 1.155\,(X_4) + 67.68$$

Where X_2 is agility, X_3 is balance, and X_4 is the arm and shoulder strength item.

INTERPRETATION

Although little has been done in the area of hand-eye coordination in physical education, its importance to motor activities seems apparent. However, in view of the very low correlation of .048 between the accuracy throw and the criterion of tennis ability, there is obviously very little relationship between the two. This is difficult to understand as tennis requires precision of arm, hand, and body movement for the most effective results when stroking or serving. And coordination is needed to move the arm and hand to meet what the eyes are seeing. Though throwing at a distant target is considered a part of hand-eye coordination according to McCloy (10), it is possible that the test measured other elements as well as the quality of hand-eye coordination. At any rate, the indication of this study has shown no apparent relationship between the accuracy test, which was used as a measure of hand-eye coordination, and tennis ability. This does not support the evidence found in studies by Martus (46) and Bates (34).

Agility, as reported by this study and similar studies in the field, has a positive and significant relation (r= .412) to the criterion. This finding was in accord with the studies conducted by Mohr and Haverstick (48), Lafuze (44), Gates and Sheffield (36), Wettstone (57), and Beise and Peaseley (22). Two of the studies involved groups of different levels of skill upon which comparisons were made with agility. The criterion for the other three studies was volleyball, games ability, or gymnastic skill. Unusual, however, and unexplainable by the writer, were the correlations found for agility and the Broer-Miller test (r = .430), the Dyer test (r = .318), and the skill ratings (r = .310). The Broer-Miller test, which allows the individual to stand in place to perform the requirements of the test, had the highest correlation of the three tennis ability tests when measured with agility. Both the Dyer test and the skill ratings demanded an element of agility for a successful test performance, yet they had the lower relationship with agility.

Static balance, as measured by the stick balance test, was found to have a significant relationship to tennis ability. A correlation coefficient of .432 was found for this factor of balance as it is of necessity in performing the tennis serve and the proper movement of the body into and during the stroking of the forehand and backhand. Results of this balance factor agree with similar studies done in related areas. Slater-Hammel (53), Estep (33), Gross and Thompson (37), and Espenschade, Dable, and Schoendube (31) reported that balance had a significant and positive relationship to their criterion measure.

The arm and shoulder girdle strength variable was the highest single correlation to the criterion. The test used to measure this quality was the basketball throw from the Scott Motor Ability Test, in which the subject attempts to throw the basketball as far as possible using any throwing technique. It is possible that the arm and shoulder strength needed to throw a basketball a distance is also the strength needed to exert the power necessary to execute some of the fundamental skills of tennis. Not only may the source of strength be the same for these two factors, but there may be a relationship in the coordination pattern depending upon the way the ball is thrown. Evidenced by the information received by the correlation, arm and shoulder strength is an essential component of tennis ability.

The other test of strength given to the subjects in this study was the grip strength test. When correlated with the final criterion, a very low relationship ($r = .012$) was found. This may indicate the grip strength as a factor in tennis ability is not important, or that the college woman possesses sufficient grip strength to perform the skills of tennis.

It was interesting to note the very low correlation found between these two measures of strength. Evidently, according to the information found in this study, they are not related. Perhaps the low coefficient can be explained by the fact that the basketball throw has a degree of coordination involved for its effective performance, whereas the grip strength test is a measure of strength alone. The following studies reported a positive, but sometimes low, relationship between the criterion and strength scores: Lamp (45), Wessell and Nelson (56), Tinkle and Montoye (54), Hinton and Rarick (38), Anderson (16), Owens (50), Carpenter (27), Hook (39), and McCloy (47).

The negative correlation found for height with the criterion would appear to indicate that there was a tendency for the shorter girl to be the better performer in tennis than her taller classmate. Low relationships were evidenced by Watson (55), Pierson (51), Baacke (17), and Espenschade (32) in their studies which included a measurement of height. More substantial relationships were reported in studies done by Cozens (28), Krakower (42), Bemies (23), and Brietinger (24).

The single correlations which were reported to relate highest with the criterion, were found to have the highest multiple correlation coefficient with tennis ability when combined. This was true for multiple correlations with the two highest single variables, with the three highest variables, and also with the four highest single variables. At this point, however, the addition of variables to the multiple correlation did not have a great effect on the value of the correlation coefficient.

A multiple correlation of .525 was found with balance and arm and shoulder strength. The combination of agility, balance, and arm and shoulder strength produced a .622 multiple correlation with the tennis ability criterion. By adding height to these three variables, the coefficient only increased by .003 to become .625. The best combination for all multiple correlations was agility, balance, the basketball throw, and height. The inclusion of the accuracy throw reduced the value of the multiple correlation coefficient.

The results of the individual ratings, when intercorrelated, were a .65 with Judge A and Judge C, a .78 between Judge B and Judge C, and a .83 between Judge A and Judge B. Judge C, it is to be remembered, was a combination of six tennis teachers who individually evaluated their students. Judges A and B were constant for all subjects. It was interesting to find the coefficients as high as they were in light of the situation (different rater rating at different times). Another unusual occurrence is the fact that the instructors rated their students lower in almost every case than did the two raters.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purposes of this study were 1) to find the relationship between various selected components of motor ability to tennis ability development and 2) to compute the prediction equation for the development of tennis ability using these selected factors.

A random sample of thirty-three subjects were selected from seven beginning tennis classes held at the University of North Carolina at Greensboro in the spring semester of the school year 1965-66.

Tests measuring balance, hand-eye coordination, strength, agility, and height were given to each of the subjects during the month of March. In May, the subject's tennis ability was measured by the Dyer Backboard Test of Tennis Ability, the Broer-Miller Forehand-Backhand Drive Test, and a tennis skill rating.

Intercorrelation, multiple correlations, and a prediction equation involving three variables were determined for the scores on the tests administered to the subjects.

The following conclusions were drawn from the results of this study:

1. Agility, balance, and arm and shoulder girdle strength are important elements of tennis ability development.

2. There is no relationship between the criterion and measures of grip strength or hand-eye coordination, as found in this study.

3. The shorter college woman tended to be the better performer in tennis than her taller classmate, although this finding was not significant.

4. The highest multiple correlation found for this tennis criterion was the combination of agility, balance, arm and shoulder girdle strength, height, and grip strength.

5. The most economical (time factor) combination of elements in this study for the prediction of tennis ability development was agility, balance, and arm and shoulder girdle strength with a multiple correlation of .622.

6. The tennis rating form devised for this study was found to have a significant relationship with the Dyer and the Broer-Miller tests of tennis ability.

Recommendations for further study include the following three points:

1. Investigate other areas of motor ability (endurance, flexibility, motor educability, force, speed, etc.) and their relationship to tennis performance.

2. Related characteristics, such as interest, aggressiveness, determination, concentration, etc., may have

some influence in developing tennis ability and would be helpful, if it is possible to reliably measure these qualities, to predict ability in tennis.

3. Investigate the relationship of motor ability qualities to tennis ability in advanced tennis classes and club groups.

4. Investigate the effectiveness of this regression equation to predict tennis ability.

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APPENDIX

TEST DESCRIPTIONS

I. BALANCE (10)

Equipment: One stop watch and a wooden stick measuring one inch square by twelve inches long.

Description: The subject balanced her body while standing erect on one foot when in contact with the stick. Each subject had three trials when the stick was running lengthwise under the supporting foot. Three more trials were taken when the stick ran crosswise under the ball of the supporting foot. A demonstration of this test was given.

Scoring: The watch was started as soon as the subject lifted her non-supporting foot off the floor. Time was stopped when the subject stepped off the stick or when some part of her body touched the floor. A trial was considered completed at the end of sixty seconds and the subject was then told to step off the stick. Each trial was recorded. The total of the six trials was the final score.

II. HAND-EYE COORDINATION (35)

Equipment: Tape measure, one rubber ball (tennis ball size), and colored masking tape.

Description: The subject stood behind a restraining line twelve feet from the target. The target was made of four concentric circles. The smallest, the bull's eye, was one inch in diameter. The next smallest was of eleven-inch diameter, then one of twenty inches, and the fourth and largest circle had a thirty-inch diameter. No practice throws were given. The subject threw a total of five balls in any manner attempting to have the ball touch the bull's eye.

Scoring: A ball striking the bull's eye counted ten points; the eleven-inch-diameter circle scored five, the next circle of twenty inches gave three points, and the largest circle counted one point. The ball that struck a line was given the highest of the two point values. Any ball that was thrown when the subject touched or stepped over the restraining line was counted as one of the five throws but scored as a zero.

III. HEIGHT

Equipment: Detecto-Matic Scale.

Description: The subject was instructed to remove her shoes and get on the scale so that she faced away from the measuring apparatus. All were told to stand erect and to fix their eyes at a point straight ahead.

Scoring: The test administrator adjusted the height apparatus so that it rested lightly atop each subject's head. The measurement was read to the nearest quarter of an inch and recorded.

IV. GRIP STRENGTH

Equipment: Grip dynamometer (rectangular type).

Description: The subject was instructed to grip the instrument in the dominant hand. One practice trial was given so that the grip could be checked and corrected if necessary. The indicator of the instrument faced away from the palm of the hand.

Scoring: The number of units shown by the indicator was recorded as the score.

V. BASKETBALL THROW FOR DISTANCE (13)

Equipment: Basketball, tape, and tape measure.

Description: The subject was given three throws with a basketball attempting to throw the ball as far as possible. The throws were made from behind a restraining line.

Scoring: The farthest of the three balls thrown was measured and recorded.

VI. AGILITY (1)

Equipment: Stop watch, tape, and a tape measure.

Description: The subject was instructed to move between the two parallel lines, which were eight feet apart, as many times as possible in thirty seconds. The movement was a side-step pattern in which neither foot crossed in front of or behind the other when performing this test. All lines had to be touched or crossed over in order to receive credit. Each subject started with one foot contacting one of the two lines.

Scoring: The number of times each line was reached by the subject in thirty seconds was recorded as the agility score.

VII. DYER BACKBOARD TEST OF TENNIS ABILITY (30)

Equipment: A flat wall space, tape, tape measure, racket, a dozen balls (minimum), a box, and a stop watch.

Description: The subject, while standing behind a five-foot restraining line, was to stroke the ball against the wall as often as possible within a thirty-second interval. The subject began with two balls in her hand. If the ball was hit at such an angle or speed that it would be to the disadvantage of the subject to continue playing it, the participant could put another ball into play. When the subject used the two balls she began with, she could take two more balls from the box at the restraining line. This practice could be continued at will throughout the trial. Any ball that did not reach the wall on a fly, hit above the three-foot line, or was hit when the subject was on or over the restraining line, did not receive credit. Each subject had three trials of thirty seconds each.

Scoring: The number of times the ball was hit against the backboard from behind the restraining line above the three-foot line on the wall was recorded for each of the three trials. The sum of the three trials was the final score.

VIII. BROER-MILLER FOREHAND-BACKHAND DRIVE TEST (25)

Equipment: Tape measure, twenty-eight tennis balls, one regulation court, rope, tennis racket, two standards of eight-foot height, and two boxes.

Description: The subjects, while standing behind the baseline, attempted to hit fourteen forehand drives over the net into the deep portion of their opponent's court by using a courtesy forehand stroke. Fourteen balls were hit in a backhand manner. The subject tried to place the ball between the net and a rope four feet above it and running the width of the court.

Scoring: Any ball passing between the net and the rope received full value of the area in which the ball landed. Half credit was given when the ball passed over the rope. The final score was the total of the twenty-eight trials.

IX. TENNIS SKILL RATING

Equipment: Skill rating forms, regulation court, and tennis rackets and balls.

Description: The judges were instructed to rate tennis subjects according to the characteristic that best described their skill. All the characteristics were relative to the beginning tennis player and the results of play, not form, were to be evaluated.

Scoring: Multiply the descriptive characteristic by the success of each stroke. Example: If the serve is rated as #4 (softly hit) and the success is #3 (minority of the time), then the score for this area is 12. Add the three categories together after multiplication and to this add the descriptive score of "ability to move" for the final score. The higher the score on this rating, the poorer the performance.

SAMPLE OF INDIVIDUAL SCORE CARD

NAME ____________________ DORM ________________

BALANCE TEST: ____

____ ____
____ ____
____ ____

BROER-MILLER TEST

____ ____ ____ ____
____ ____ ____ ____
____ ____ ____ ____
____ ____ ____ ____
____ ____ ____ ____
____ ____ ____ ____
____ ____ ____ ____

GRIP STRENGTH: ____

AGILITY: ____

BASKETBALL THROW: ____

HEIGHT: ____

ACCURACY THROW: ____

____
____
____
____
____

TFH____ TBH____

DYER'S TEST

____
____
____

TOTAL_______

April 26, 1966

Dear

The final tests are about to be given to several of your students who are serving as subjects in my thesis study. As their tennis unit comes to a close, it will be necessary for each of these girls to be rated with reference to her tennis ability.

When asked at the beginning of the semester, you consented to subjectively grade these students. Enclosed find rating sheets for each girl who has been randomly selected from your class.

The number of class meetings in which the student has participated may influence her level of performance at the time her ability is judged. The rating of the subjects should be coordinated so that every subject has the same opportunity to perform well. Therefore, if it is at all possible, this evaluation of their performance should be completed the week of May 2-6.

Two very important points should be kept in mind while evaluating. First is that all characteristics (speed, accuracy, etc.) are relative to a beginning tennis player, and secondly, that only the <u>results</u> of strokes, the serve, and the pattern of moving ability, <u>not form</u>, are to be evaluated.

Your cooperation and assistance is appreciated.

Thank you,

Jean Pankonin
Graduate Student

Name ______________________ Date of Evaluation _____

Please indicate by check mark the description that best characterizes this subject's <u>serve</u>.

____1. Speed with placement
____2. Controlled variation of speed or placement
____3. Ordinary serve without speed and placement
____4. Softly hit-travels in slight arc after leaving racquet
____5. Lob serve

With this description in mind, what proportion of the time is the <u>serve</u> successful (hits in the proper service area)?

____1. Successful majority of time (approx. 60% and above)
____2. Successful half of the time (approx. 40-60%)
____3. Successful minority of the time (approx. 40% and under)

Please indicate the description that best characterizes this subject's <u>forehand</u> drive.

____1. Is low and deep (back half of court)
____2. Is high but falls deep in court
____3. Is of medium height and falls in mid-court
____4. Is softly hit, although it has some direction (right or left side)
____5. Is softly hit, but without direction.

With this description in mind, what proportion of the time is the <u>forehand</u> drive successful (hits in playing court)?

____1. Successful majority of time (approx. 60% and above)
____2. Successful half of the time (approx. 40-60%)
____3. Successful minority of time (approx. 40% and under)

Please indicate the description that best characterizes this subject's <u>backhand</u> drive.

____1. Is low and deep (back half of court)
____2. Is high but falls deep in court
____3. Is of medium height and falls in mid-court
____4. Is softly hit, although it has some direction (right or left side)
____5. Is softly hit, but without direction.

With this description in mind, what proportion of the time is the <u>backhand</u> drive successful (hits in playing court)?

____1. Successful majority of time (approx. 60% and above)
____2. Successful half of the time (approx. 40-60%)
____3. Successful minority of time (approx. 40% and under)

Please indicate the description that best characterizes this subject's <u>ability to move</u>.

____1. Is alert, anticipates, has good stroking position and is continually moving.
____2. Gets into proper position quickly.
____3. Is average in ability to move.
____4. Is slow moving, which has some effect on her stroke production.
____5. Very slow, which penalizes her return of shots.

TABLE III

BETA COEFFICIENTS AND PREDICTION COEFFICIENT CONSTANTS

	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Beta Coefficients	-.103	.165	.267	.327	.144	-.196
Prediction Coefficient Constants	-.545	1.192	.096	1.155	.426	-2.176

TABLE IV

RAW SCORES MADE BY THE SUBJECTS ON THE ACCURACY THROW, THE AGILITY, AND THE BALANCE TESTS

Subject	Accuracy Throw	Agility Test	Balance Test
1.	7	21	205
2.	10	19	82
3.	18	17	17
4.	11	21	120
5.	25	24	166
6.	10	25	72
7.	14	20	110
8.	24	14	91
9.	19	18	194
10.	15	24	241
11.	15	20	141
12.	18	26	303
13.	7	19	126
14.	17	22	49
15.	10	25	116
16.	12	21	37
17.	19	24	191
18.	14	19	106
19.	24	21	156
20.	15	26	34
21.	19	21	238
22.	17	24	171
23.	17	23	189
24.	21	18	110
25.	10	17	112
26.	13	21	77
27.	11	19	185
28.	15	28	290
29.	10	32	177
30.	25	26	102
31.	16	21	118
32.	19	24	263
33.	15	21	95

TABLE V

RAW SCORES MADE BY THE SUBJECTS ON THE BASKETBALL THROW, THE GRIP STRENGTH, AND THE HEIGHT TESTS

Subject	Basketball Test	Grip Strength	Height Measurement
1.	30	40	68.25
2.	31	60	64.00
3.	33	74	66.25
4.	28	65	65.75
5.	46	80	62.00
6.	49	77	68.00
7.	31	63	64.50
8.	35	60	61.00
9.	26	56	64.25
10.	36	54	62.00
11.	45	46	61.25
12.	51	69	57.75
13.	29	69	63.75
14.	28	54	64.75
15.	43	61	66.25
16.	35	60	66.25
17.	36	51	65.00
18.	30	64	62.00
19.	45	60	64.00
20.	33	58	64.50
21.	41	54	57.25
22.	37	66	66.75
23.	31	67	65.00
24.	29	64	64.00
25.	34	67	66.50
26.	35	60	65.25
27.	36	68	63.75
28.	36	44	62.75
29.	52	60	67.00
30.	43	60	68.00
31.	29	54	62.25
32.	48	50	64.00
33.	43	58	63.25

TABLE VI

RAW SCORES MADE BY THE SUBJECTS ON THE TENNIS SKILL RATINGS

Subject	Judge A	Judge B	Judge C
1.	28	17	36
2.	19	15	21
3.	44	21	40
4.	22	33	43
5.	6	6	14
6.	10	13	35
7.	12	11	31
8.	24	28	25
9.	35	44	26
10.	7	9	26
11.	44	49	50
12.	21	23	28
13.	41	31	46
14.	38	30	21
15.	30	18	38
16.	27	37	40
17.	32	39	50
18.	15	16	17
19.	22	15	27
20.	22	24	34
21.	15	16	12
22.	26	14	23
23.	38	36	46
24.	49	44	49
25.	18	17	37
26.	44	44	21
27.	13	15	15
28.	11	6	13
29.	22	13	18
30.	21	17	28
31.	30	33	43
32.	8	8	9
33.	5	5	5

TABLE VII

RAW SCORES MADE BY THE SUBJECTS
ON THE TESTS OF TENNIS ABILITY

Subject	Broer-Miller	Dyer	Tennis Skill Ratings	Combination of Broer-Miller Dyer Skill Ratings (T-Scores)
1.	47	30	81	139
2.	45	39	107	158
3.	27	30	57	122
4.	37	26	64	123
5.	67	44	136	185
6.	40	31	104	144
7.	47	41	108	162
8.	48	36	85	149
9.	20	31	57	120
10.	95	51	120	202
11.	33	26	19	108
12.	101	44	90	187
13.	35	32	44	125
14.	36	24	73	123
15.	56	44	76	161
16.	63	25	58	134
17.	51	37	41	139
18.	58	36	114	162
19.	26	38	98	145
20.	58	45	82	166
21.	56	49	119	181
22.	51	33	99	151
23.	7	28	42	105
24.	33	38	20	125
25.	45	30	90	141
26.	40	32	53	130
27.	54	46	119	177
28.	65	44	132	183
29.	75	40	109	175
30.	43	33	96	146
31.	21	28	53	116
32.	48	39	137	168
33.	90	39	147	192

TABLE VIII

THE SUMS, MEANS, AND STANDARD DEVIATIONS OF THE RAW SCORES

Test	Sums	Means	Standard Deviations
Accuracy Throw	512.00	15.52	4.951
Agility	721.00	21.85	3.624
Balance	4,684.00	141.94	72.841
Basketball Throw	1,214.00	36.79	7.407
Grip Strength	1,993.00	60.39	8.853
Height	2,128.25	64.4924	2.35724
Broer-Miller	1,618.00	49.03	20.848
Dyer	1,189.00	36.03	7.308
Skill Rating	2,830.00	85.76	34.135
Criterion	4,944.00	149.82	26.168