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Maximal grip strength and perceived tennis gripping force of college-age females with various tennis experiences

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MAXIMAL GRIP STRENGTH AND PERCEIVED TENNIS GRIPPING FORCE OF COLLEGE-AGE FEMALES WITH VARIOUS TENNIS EXPERIENCES

by

Ann Sastri Bean

An Abstract

of a project submitted in partial fulfillment
of the requirements for the degree of
Master of Science in the School
of Health, Physical Education
and Recreation at
Ithaca College

July, 1974

Project Advisor: Dr. Harold H. Morris

ABSTRACT

The purpose of this investigation was to compare the maximal dominant hand grip strength and the perceived grip force used while gripping a tennis racket of female college students with varying tennis backgrounds. The subjects (N = 45) were members of the women's varsity tennis team, physical education majors, and GIPPE participants.

On each of the three consecutive days of data collection each subject was given three trials gripping a tennis racket spaced thirty seconds apart. They were then required to repeat the same effort five times, using the cable-tensiometer with a thirty-second rest between trials. Following a one-minute rest each subject was required to exert two, all-out maximum grip strength trials with a one-minute rest between trials.

The means and standard deviations were computed for maximum and perceived scores. An analysis of variance for trials x days was compuated for maximum strength scores. This was followed by an intraclass correlation based on appropriate mean scores calculated in the analysis of variance. To determine differences between groups, three independent analyses of variance were computed.

It was concluded that there were no significant differences

between the perceived tennis grip of varsity tennis team members, physical education majors, and GIPPE participants. In addition, the maximum grip strength scores did not significantly differ between the three sample groups. Finally, the investigator concluded that a perceived grip strength can be consistently reproduced by college age females.

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A Project Presented to the Faculty of

the School of Health, Physical

Education and Recreation

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July, 1974

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CERTIFICATE OF APPROVAL

M. S. PROJECT

Ann Sastri Bean

submitted in partial fulfillment of the requirements
of the degree of Master of Science in the
School of Health, Physical Education
and Recreation at Ithaca College
has been approved.

Project Advisor: .

Candidate: .

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Chapter I

INTRODUCTION

Kinesthetic sense is an important factor in learning and perfecting a motor skill. Many functions of kinesthesis are important elements in teaching physical education skills such as coordination of body movements, development of skills, locomotion, positive body control, manipulation, balance, and an appreciation of weights and forces. Certain concepts of physical education are also related to kinesthesis such as perception of movement, tension or resistance, position, space perception, balance, effort, and relaxation(29). The physical educator must consider kinesthesis when teaching a new skill. This involves an awareness of the position or movement of the body and its parts. "An individual learns new skills from memory of former sensations and consciousness of present ones which enables one to judge the corrections of his movements"(5).

Numerous activities require a gripping action such as golf, softball, field hockey, fencing, track and field, tennis, and badminton. Many educators instruct the learner to grasp the implement "firmly." What does this mean to the student? From this cue, it is improbable that the learner can interpret how he should be grasping the implement.

It would be much more beneficial to tell the student to grasp her tennis racket at a percentage of her maximum grip.

Statement of the Problem

The purpose of this investigation was to compare the maximal dominant hand grip strength and the perceived grip force used while gripping a tennis racket of female college students with varying tennis backgrounds.

Significance

Kinesthesis is an important factor in learning a new skill. Those activities concerned with the gripping action are of major concern to the physical educator. When teaching a particular skill, how does one describe the degree of grip strength needed for optimum success? In tennis, the concern is great, for a grip too tight or too loose assures less success than if the grip is correct. Since this activity involves gripping, the ability to consistently exert the same pressure on the instrument is also important. As a result, the author suggests that more research is needed in this area of obtaining the optimal grip strength for a sport such as tennis. It is necessary to determine if an individual can perceive one's intended grip and reliably reproduce those efforts.

Scope of the Problem

The primary purpose of this investigation was to determine if grip strength differences, both maximum and perceived tennis grip, existed among the women's tennis team, female physical education majors with tennis experience, and female participants in the GIPPE program, also with tennis experience. The subjects were classified into three groups. One group was the 1973 undefeated women's tennis team at Ithaca College consisting of fifteen members. The second group was fifteen female physical education majors at Ithaca College and the third group was fifteen participants in the GIPPE program also at Ithaca College.

Definition of Terms

1. Kinesthesis--"The sense which informs an individual regarding the position of the segments of the body, their force, rate and direction of movement"(31). The term may be expanded and defined as: (a) the ability to maintain a constant pressure against an object, (b) the ability to move the limbs to certain positions, and (c) the ability to maintain balance or achieve a vertical position(1).

2. Physical Education Major with Tennis Experience--a female physical education major who has fulfilled the requirements of the major's tennis class.

3. General Instructional Program of Physical Education

Participant--an Ithaca College student who has met the requirements of tennis class offered by GIPPE.

4. Varsity Tennis Team Member--a female tennis player who has competed on the intercollegiate level.

5. Maximum Grip Strength--the mean of two trials per day, over three consecutive days with a one-minute rest between trials.

6. Perceived Grip Strength--a mean of grip strengths perceived when gripping a tennis racket during the forehand stroke.

Research Hypothesis

The varsity tennis team members will have a higher grip strength, more accurate perception of grip strength, and greater consistency when compared to physical education majors and GIPPE participants, both with tennis experience.

Statistical Hypothesis

There will be no significant differences in maximal grip strength, perceived grip strength, or the consistency of the perceived grip strengths between the women's varsity tennis team, physical education majors, and GIPPE participants with tennis experience.

Delimitations

This study was delimited by:

1. The size and selection of subjects, which was forty-five female college students enrolled in Ithaca College.

2. The variables considered, which were the maximum grip strength of the dominant hand and the perception of force with which they grip a tennis racket.

3. The number of days and trials given within days which was two maximum trials and five submaximum trials on each of three consecutive days.

4. The measurement instrument used which was the cable-tensiometer.

Limitations

This study was limited by:

1. Due to the sample of subjects of only female college age students.

2. Classification of students is a proper representation of skill and tennis experience.

3. Accuracy and consistency of scores recorded on the cable-tensiometer.

4. Only dominant hand was assessed.

Chapter II

REVIEW OF LITERATURE

The review of literature for the purposes of this investigation had as its concentration the following important areas: (1) the measures of kinesthesis, (2) the role of kinesthesis in skill acquisition, (3) the importance of kinesthesis in early or late stages of skill acquisition, (4) the relationship of kinesthetic perception to selected motor skills, and (5) summary.

The Measures of Kinesthesis

Physical educators are continually searching for and experimenting with new techniques and methods of teaching motor skills. An understanding of the kinesthetic sense is a systematic approach to one method of performance and teaching. A difficulty in applying principles of kinesthesis to the teaching of motor skills has been the lack of understanding of primary factors involved in this sense. However, a factor analysis technique enables an investigator to isolate factors that cannot otherwise be separated by experimentation(31). Witte(31) was one of the first to analyze the measures of kinesthesis. Test items used in the investigation were obtained from tests suggested by authors in previous kinesthetic studies and original tests developed by Stevens(41). He

administered 36 tests to 100 nonphysical education students enrolled at Indiana University. From this experiment, 10 factors emerged. In addition, seven factors were identified from the 33 tests which suggests that kinesthesis cannot be thought of as a general trait.

The following year, Weibe(29) endeavored to determine test reliabilities, validies and interrelationships and perfect a short battery of tests of kinesthesis. There were 21 tests of kinesthesis administered to 15 collegiate varsity men and 15 collegiate men who never lettered. She found 15 tests that had reliability coefficients which would recommend them as useful. However, no one test exhibited a validity coefficient high enough to warrant its use as a single test. There were low correlations between tests which indicates that there is no general kinesthetic sensitivity but that there are probably numerous specific factors. Kinesthetic differences were also found in favor of the athletes.

Several of the same conclusions were found by Scott(26). In that investigation, twenty-eight measures of kinesthesis and two of motor ability were given to one hundred college women. Scott found no single test adequate in validity when compared with the criteria. She also found that several combinations of tests appear to have a validity value satisfactory for further use. The sensation of kinesthesis is evidently made up of many elements or forms of response.

An attempt was made by Magruder(37) to learn more about the testing for kinesthesis by experimenting with various methods of

administering tests. The results of known tests of kinesthesis were compared when given by three different methods of testing ninth and tenth graders. The three methods were as follows: (a) one visual demonstration with verbal instructions while blindfolded; (b) no demonstration, one practice while watching the results of effort and blindfolded when tested; and (c) no demonstration, one practice while blindfolded, verbal instructions and tested while blindfolded. He found that method (c) was better in all instances (total scores and overall means). From this study one could conclude the best method (of these three) to test for kinesthesis was in which the subject was given one practice while blindfolded, no demonstration and verbal instruction.

Another study involving measures of kinesthesis was done by Johnson(35). The purpose was to establish valid and reliable tests to measure kinesthesis in the area of space. With the exception of three tests the kinesthetic tests of space orientation had adequate reliability. However, no one test had validity by itself, though several combinations of tests seemed adequate. As found previously, there was a specificity of function.

A recent study involving the measuring of kinesthesis was conducted by McEachran(38). The purpose was to investigate the consistency and accuracy of measuring the perception of submaximal grip strengths. The subjects involved were forty-five male college students assigned to three groups of submaximal grip strength: either 75 per

cent, 50 per cent, or 25 per cent of their maximum strength. The measuring instrument used was the cable-tensiometer with an orthopedic attachment. The data were subjected to an analysis of variance followed by further analysis. The results of this study indicated that a given level of submaximal grip could not be precisely perceived. He also found that a submaximal grip strength of 75 per cent was overestimated and underestimated, while 25 or 50 per cent was continually overestimated.

Role of Kinesthesis in Skill Acquisition

One of the first studies involving muscle tension and kinesthesis was conducted by Henry(12). His study involved two separate tests--one of constant position and one of constant pressure. The subjects used were 12 upper division physical education majors and graduate students. It was found that the subjects were accurate at maintaining a constant position on the hand-hold while the pressure was changing. The results imply that subconscious reactions are made by the kinesthetic sense.

Kinesthesis is the sensation of feeling muscularly a position or movement. The effect of fatigue of the arm muscle was investigated by Dial(33). Fatigue was defined as an individualized subjective feeling of tiredness in the active muscle of the arm. Five tests of kinesthesis were given to fifty volunteers at the University of Iowa. Her conclusion was that the type of fatiguing activity used in the study appeared to have

no appreciable effect on the kinesthetic performance of the subjects tested. One may generalize that tasks similar to the five used are not affected by fatigue.

Horton(34) determined the effect of three variables of a simple kinesthetic arm positioning task. The three variables used were direction of movement, load or resistance, and knowledge of results. The simple kinesthetic task involved a movement initiated and carried out by the subject without benefit of visual or auditory cues with tactile cues reduced as low as possible and carried out by the subject without benefit of visual or auditory cues with tactile cues reduced as low as possible and excluding general body balance. The subjects were eighty eighth-grade girls. One half performed with knowledge of results and one half did not have knowledge of results. It was concluded that knowledge of results had a significant influence on the performance of a kinesthetic arm positioning task. It was also found that the direction of movement with the pull of gravity or against the pull of gravity had no observable effect upon performance of the kinesthetic arm positioning task.

A better understanding of kinesthesis would contribute to comprehension of the motor learning process. Application of additional knowledge could increase teaching effectiveness and consequently enhance learning. However, present knowledge with respect to kinesthesis is exceedingly inconclusive. Therefore Lyon(36) investigated

the effect of practice on three dynamic components of kinesthetic perception, namely force, rate, and direction of movement. The learning task required the subject, while blindfolded, to perform a novel arm movement in a prescribed direction while moving at a designated rate of speed and ending with a designated amount of force. It was found that practice requiring a high degree of kinesthetic perception resulted in significant improvement in force, speed, and direction of movement. Performance scores in the early stages of practice tended to be better predictors of the final performance than initial scores. Therefore the hypothesis that certain dynamic components of kinesthetic perception, namely force, rate, and direction of movement, may be improved through practice directed only through kinesthetic cues, was found tenable.

Kinesthetic short-term memory also affects skill acquisition. Such an investigation was conducted by Wilberg(30). In his study visual and kinesthetic short-term memories were subjected to immediate recall, delayed (10 seconds) recall, and delayed recall with an interpolated task. Six subjects were used with five repetitions per subject. Generally, as long as the subjects were able to dwell upon the memory trace, their recall after a 10-second delay were as good as their absolute judgments. Forcing the subjects to perform an interpolated task (conversation), however, caused a rapid short-term memory decay and consequently poorer performance.

Norrie(22) investigated absolute changes and directional changes in short-term memory for the exertion of a force. The subjects used were 63 college physical education volunteers. The task involved pushing a handle forward until told to hold and release two seconds later. After a specified interval the subject regrasped the handle and attempted to reproduce the force recorded. When attempting to reproduce a force immediately, the subjects tended to exert more than the standard force which suggests that performance on immediate reproduction may be influenced by a kinesthetic aftereffect. This aftereffect dissipated by the end of 30 seconds. The presence of this aftereffect, which dissipates rapidly, has implications for distribution of practice for discrete tasks involving force reproduction. It may be necessary to allow sufficient time between trials for dissipation of the kinesthetic aftereffect. Norrie(20) conducted a follow-up study involving reinforcements for a kinesthetically monitored force. Analysis of variance indicated that multiple reinforcements improved the accuracy of performance for immediate reproduction but that the improvement was not retained over a retention interval of 30 seconds.

It has been shown that several factors affect the role of kinesthesis in skill acquisition. Henry began the investigations in 1953(12) involving constant position and constant pressure tests. Dial(33) conducted a study involving the effects of fatigue. Those tasks familiar to the subjects were not affected by fatigue. As a result of an

investigation by Horton(34), certain components of kinesthesis were thought to have improved through practice directed by kinesthetic cues only. The effects of short-term memory were studied by Wilberg(30) and Norrie(22). Norrie found that performance or immediate reproduction may be influenced by a kinesthetic feedback(22). The teacher must consider all possible factors when teaching a particular skill using kinesthetic perception.

The Importance of Kinesthesis in Early or Late Stages of Skill Acquisition

For many years there has been disagreement as to whether the relationship of kinesthesis to motor skill is more predominant in the early or later stages of learning. Two major studies have been involved with this aspect of kinesthesis. The first was done by Phillips and Summers(24). Their purpose was to determine whether or not positional measures of kinesthesis are related to motor skill, and if so, whether relationship is more evident in early stages of acquiring skill than in later stages. One hundred and fifteen college women were tested on twelve positional measures of kinesthesis. Each was classified as a fast or slow learner on the basis of improvement shown during 24 class periods of bowling. The task involved the investigator moving the subject's arm to the desired angle and holding for two or three seconds and returning it to starting position. The subject would then attempt to repeat the movement, all without assistance. They

found that there is a relationship between motor learning and positional measures of kinesthesis. They also found that kinesthesis is more related to learning in the early stages of acquiring a motor skill than it is in the later stages. Real differences also existed between preferred and nonpreferred arms in kinesthetic perceptivity.

Inversely, Fleishman and Rich(9) found that sensitivity to proprioceptive cues are more important later in perceptual-motor learning. If kinesthetic cues predominate later in motor learning then subjects who have superior sensitivity to these cues should be superior to other subjects at advanced stages of learning a complex motor task. But these subjects would not necessarily excel during initial stages of learning. The subjects used were 40 Yale University students. The limitation in this study was that they stratified a relatively small group at the median. Therefore the groups overlap and individuals in the middle of the range dominate both groups. The authors state that in spite of the limitations, the effects were shown to be in the hypothesized directions.

Kinesthesis or the sense of position and movement may be the most important sensitivity that man possesses. Where in the learning stage, however, is not quite so definite. Phillips and Summers state that the kinesthetic sense is more important in early stages of learning a motor skill than in later stages. Differing in opinion are Fleishman and Rich, who state that proprioceptive cues are more im-

portant in the later stages.

Relationship of Kinesthetic Perception to a Selected Motor Skill

An initial study involving the relationship of kinesthesis to a selected motor skill was conducted by Griffith(10). The purpose was to determine the importance of the kinesthetic sense in the development of the skill of driving a golf ball. He split twelve novice golfers into two groups. Group A was taught with visual and audio aids, while Group B was taught to feel the correct position and received instruction while blindfolded for four weeks and unblindfolded for the next four weeks. Group B started more slowly than Group A, but by the end of the third week had surpassed Group A and maintained it. Griffith concluded that the kinesthetic sense plays a very important part in learning to drive the golf ball.

Several years later, Young(32) studied the relationship of kinesthesis to selected movements commonly used in gymnastics and sport activities. The 37 women majoring in physical education at the University of Iowa were given 19 tests of kinesthesis while blindfolded. Young found three tests of kinesthesis with high validity. He also stated that there was no real relationship between tests of kinesthesis and general motor ability.

A similar investigation was carried out by Roloff(39). His purpose was to develop a battery of tests to measure kinesthesis and

investigate the relationship, if any, between kinesthesis and the learning rate of college women in certain motor skills. The subjects were 200 college women with a mean motor ability T-score of 50.46. Two instructors taught four classes--each teaching one experimental and one control class. No new technique was used, just a change of emphasis. Kinesthesis was stressed by asking the students to feel the movement, feel themselves perform as watched, do drills with eyes closed, and more visual aids were used. Roloff found eight tests of kinesthesis to have merit. However, there was no statistically significant evidence that the experimental methods of teaching used were superior to the control method. Therefore, the stressing of kinesthesis had no advantageous effects upon the learning of selected motor skills.

The relationship of kinesthesis to wrestling was investigated by Mumby(18). Subjects used were 21 students from intermediate and advanced classes and rated by two judges. The two tests used--constant pressure and constant position--were previously mentioned by Henry(12). Several conclusions were drawn from this study. The ability of the subject to maintain constant muscle pressure under a changing dynamic condition was significantly related to wrestling ability as subjectively rated by the experienced wrestling instructors. It was also stated that individual differences in wrestling ability are apparently unrelated to the ability to maintain a constant arm position in a dynamic situation involving the changing of applied force.

The purpose of an investigation by Witte(31) was to determine whether or not selected measures of kinesthesis involving arm positioning were related to measures of accuracy in ball rolling. Tested were forty-seven first and second graders on four arm positioning and two ball rolling measures. The kinesthetic test involved the reproduction of 90° angles of the arm. The difference between boys and girls in kinesthetic perceptivity for arm positioning measures were not significant. Boys were found superior in their ability to roll balls. A low correlation (.2832) between the kinesthetic battery and ball scores indicates no real relationship between kinesthesis and ball rolling ability as measured by tests used in the study.

An inquiry was conducted by Sisley(40) to determine the relationship between kinesthesis and the level of skill of three groups of subjects selected for their ability in basketball, bowling, and tennis. Three groups of advanced skill were administered a four-item battery as suggested by Roloff(25). The tennis players had the highest mean score and the largest range on the kinesthetic battery, but the difference was not a significant one. There was also no relationship found between kinesthesis and skill level in basketball, bowling, and tennis.

Slater-Hammel(27) compared reaction time measures for selected groups of varsity athletes, physical education majors, music majors, and liberal arts majors. Previous studies had the limitation of not knowing whether a subject responds to kinesthetic stimulation,

to tactual stimuli, or to a complex of kinesthesis and tactual stimuli. This study was concerned with the speed with which a subject could react to sudden displacement of an arm. The subjects consisted of 80 male university students. He concluded that reaction time to arm movement was shorter than to visual stimuli for all subjects and groups. Varsity athletes had shorter overall reaction time than physical education, music, and liberal arts majors. Later a follow-up study related to kinesthesis was conducted by Slater-Hammel(28). The methodology involved subjects practicing to contract the triceps brachii at an intensity necessary to generate muscle potentials of approximately 125 microvolts. Following the trials the subjects attempted to reproduce the same muscular force. All groups tended to reproduce more than the standard muscular force as represented by 125 microvolts potential. In addition, the difference in constant errors was not significant between sexes but was for the physical education groups.

The initial investigation by Griffith(10) did show some relationship between kinesthesis and the ability to drive a golf ball. The following studies by Young(32), Roloff(25), Witte(31), and Sisley(40), however, showed little relationship to selected motor skills. Perhaps the terms kinesthesis and motor skills are too general. Specific aspects of kinesthesis may be important in specific skills only.

Summary

Is kinesthetic sense really an important factor in learning and perfecting a motor skill? The studies mentioned above have been done with certain aspects of kinesthesis in mind. Very few studies, however, relate to the gripping action. The author concludes that it is essential for students to grip at a desired effort and repeat it consistently. Therefore it is necessary to determine if an individual can perceive one's intended grip and reliably reproduce those efforts.

Chapter III

METHODS AND PROCEDURES

The purpose of this chapter is to present the methods and procedures employed in this investigation. For discussion this chapter has been divided into the following subtopics: (1) description of the subjects, (2) testing equipment, (3) testing procedures, (4) analysis of data, and (5) summary.

Description of Subjects

The subjects involved in this investigation were 45 female Ithaca College students. The subjects were classified into three groups, according to their tennis experience. One group consisted of members of the undefeated women's varsity tennis team. The second group was composed of female physical education majors with tennis experience, while the third group consisted of nonphysical education majors who had completed a GIPPE tennis course. The subjects were randomly selected from their respective populations using the random numbers method with replacement.

Testing Equipment

Since this investigation involved the consistency of measuring grip strength, a reliable instrument was needed. A study was conducted by Clark(6) to compare the effectiveness for recording muscle strength, of the following four instruments: cable-tensiometer, the Watkin-Porter strain gauge, the spring scale, and the Newman myometer. As reflected by objectivity coefficients, the cable-tensiometer was determined to have the greatest precision for strength testing. On the basis of Clark's findings, the cable-tensiometer was selected for this investigation.

An orthopedic testing attachment was installed to serve as a gripping mechanism. In order to accommodate for individual hand sizes, adjustments were possible by the use of several metal balls welded to the tensiometer cable. The cable-tensiometer was bolted to a wooden supporting structure that was fastened to a metal desk with C-clamps. A stopwatch was used in timing the rest periods.

Testing Procedures

As each subject entered the testing room she was seated in front of the apparatus and adjustments to the orthopedic attachment were made to accommodate for individual hand sizes. The measurement of each subject's grip size was recorded in order to facilitate consistency throughout the three testing days. The adjustments were

made until the second phalange of the forefinger was on the gripping bar.

On each of the three consecutive days of data collection a subject was given three trials gripping a tennis racket at the force used to execute a forehand stroke. A 30-second rest period was given between these trials. Following the trials on the tennis racket, the subjects were required to repeat the same effort five times using the cable-tensiometer with a 30-second rest period between trials. Following a one-minute rest, each subject was required to exert two maximum grip strength trials with a one-minute rest between trials. No specific verbal motivation was given by the experimenter. No results were given to the subject until after the third day of testing.

The following standardized instructions were read to each subject on the first day of testing:

> The purpose of this study is to determine the force that you use when gripping a tennis racket while executing a forehand stroke. Your first task will be to grip the tennis racket as you would on the forehand stroke on three different trials which are to be spaced thirty seconds apart. On each trial you are to concentrate on determining the force you would use when bringing the racket through a forehand stroke. During each trial you are encouraged to increase and/or decrease your gripping strength until you feel it is the effort you would use in executing the stroke.
>
> After three practice trials you then will be required to repeat that determined effort five times on the cable-tensiometer with a thirty-second rest between trials. With approximately three to four seconds remaining in each rest period I will tell you to "take the grip" and at the end of the rest period to "go."

After you have repeated your perceived grip strength you will then determine your maximum grip strength by exerting yourself on two all-out trials, with a one-minute rest between.

You will not be told your results until after the three days of testing are completed. At this time I will be more than happy to explain the results if you so desire.

Are there any questions?

Analysis of Data

Tensiometer recordings were read by the experimenter and rounded off to the next highest point value. The tensiometer recordings were then transformed into pounds force. Means and standard deviations were computed for each subject for maximum and perceived tennis grip scores.

An analysis of variance for trials x days was computed for maximum scores. An intraclass correlation, based on appropriate mean squares calculated in the analysis of variance, was computed. This procedure allowed the assessment of the reliability of the measurement schedules.

To determine differences between groups, three independent analyses of variance were computed. One was for maximum scores. The second for perceived scores and the third assessed differences in variable error scores. The variable error measured the degree of variability of a subject's perceived score about the mean of his score. The conclusions and interpretations were based on the

.05 level of significance.

Summary

Forty-five female college students enrolled in Ithaca College were required to exert what they perceived to be their grip of a tennis racket. This was followed by an all-out maximum grip. The cable-tensiometer was chosen as a reliable instrument as a result of a study conducted by Clark(6). Each subject listened to standardized instructions to facilitate consistency. An analysis of variance was computed followed by an intraclass correlation to determine the reliability of the measurement schedules. Finally, three independent analyses of variance were computed to find differences between groups.

Chapter IV

RESULTS

The results of the investigation are presented in this chapter which includes: (1) the results of an analysis of variance to determine differences between trials and/or between days, (2) the results of an intraclass correlation, (3) the results of three independent analyses of variance to find differences between groups, and (4) summary.

The means and standard deviations of perceived scores (Table I) and maximum scores (Table II) were computed. The physical education majors had the highest mean perceived score of 36.95 pounds and a maximum mean score of 54.47 pounds, while the varsity members had the highest maximum mean score of 56.90 but was second to the majors with a perceived mean score of 32.16 pounds. However, the GIPPE students were lowest on both perceived and maximum scores with 29.12 and 49.22 pounds.

Results of an Analysis of Variance to Determine Differences between Trials and/or between Days

To determine day-to-day and trial-to-trial variations, an analysis of variance was computed for maximum strength scores. The

TABLE I. MEANS AND STANDARD DEVIATIONS OF PERCEIVED SCORES

Treatment Group	Varsity	GIPPE	PE
Sample Size	15	15	15
Mean Score	32.16	29.12	36.95
Standard Deviation	9.87	10.52	13.61

TABLE II. MEANS AND STANDARD DEVIATIONS OF MAXIMUM SCORES

Treatment Group	Varsity	GIPPE	PE
Sample Size	15	15	15
Mean Score	56.90	49.22	54.47
Standard Deviation	12.28	9.30	12.50

results are presented in Table III. The differences, both day-to-day and trial-to-trial, were nonsignificant. The F ratios were less than 1, 1.45, and 1.29. This illustrates that the extraneous variables, such as fatigue, did not significantly influence the data.

Results of an Intraclass Correlation

Following the analysis of variance an intraclass correlation was computed to establish the reliability of the measurement schedules. As revealed in Table IV the maximum strength scores exhibited high reliability (R = 0.957). In Table V the reliability of perceived groups is shown. The highest (R = 0.947) was for trials of physical education students followed by GIPPE (R = 0.936) and varsity (R = 0.898). As a result of these analyses the measurement schedules were considered to be reliable and free from systematic error variance.

Results of Three Independent Analyses of Variance to Find Differences between Groups

To determine if differences existed between groups, three independent analyses of variance were computed. The results of the analysis for maximum strength scores are shown in Table VI. With two and forty-two degrees of freedom at the .05 level of confidence, an F ratio of 3.23 is required for significance. The obtained F value for the test of differences between the means of groups for maximum strength was 1.841. Thus, the null hypothesis was obtained and it was

TABLE III. ANALYSIS OF VARIANCE OF THE DAY-TO-DAY AND TRIAL-TO-TRIAL VARIATIONS IN MAXIMUM STRENGTH SCORES

	df	SS	MS	F
Within Subjects	225			
Days	2	49.57	24.78	<1
Groups x Days	4	53.63	13.41	<1
Days x Groups within Subjects	84	2894.18	34.45	
Trials	1	3.88	3.88	<1
Groups x Trials	2	2.84	1.42	<1
Trials x Subjects within Groups	42	736.69	17.54	
Trials x Days	2	42.25	21.12	1.45
Groups x Days x Trials	4	74.93	18.73	1.29
Trials x Days x Subjects within Groups	84	1224.09	14.57	

TABLE IV. INTRACLASS CORRELATION OF MAXIMUM STRENGTH SCORES, BASED ON A MEASUREMENT SCHEDULE OF TWO TRIALS PER DAY, FOR THREE DAYS
(N = 45)

MS True	MS Days	MS Trials	R
124.73	8.93	15.44	0.957

TABLE V. INTRACLASS CORRELATIONS OF PERCEIVED SCORES BASED ON A MEASUREMENT SCHEDULE OF FIVE TRIALS PER DAY FOR THREE DAYS (N = 45)

	MS True	MS Days	MS Trials	R
Varsity	87.60	24.78	24.58	0.898
GIPPE	103.64	16.36	24.48	0.936
PE	175.24	22.88	33.99	0.947

TABLE VI. ANALYSIS OF VARIANCE OF MAXIMUM STRENGTH SCORES TO DETERMINE DIFFERENCES BETWEEN GROUPS

Sources of Variation	df	SS	MS	F
Between Groups	2	2,772.69	1,386.34	1.841
Subjects within Groups	42	31,620.25	752.86	
Total	44	34,392.39		

concluded that the three groups did not differ significantly in maximal strength. A similar analysis was computed for the perceived scores. These results are presented in Table VII. With two and forty-two degrees of freedom an F ratio of 3.23 is also required for significance. The obtained F ratio for differences between perceived mean scores was 1.759. Thus it was concluded that the three sample groups did not differ significantly in the tension they recorded as their perception of the force used in gripping a tennis racket.

The final analysis of variance was computed to determine if differences existed between variable error scores. The means and standard deviations of the variable error score are shown in Table VIII. The majors exhibited the highest mean score (6.72) and a standard deviation of 2.37. The varsity members had the lowest standard deviation of 1.74, while GIPPE students had the lowest mean score of 5.70. The analysis of variance variable error scores are presented in Table IX. The variable error measures the degree of variability of a subject's perceived scores about the mean of his perceived value. The obtained F ratio of 0.899 was nonsignificant. Therefore it was concluded that the three groups did not differ significantly in the variability or consistency of recording perceived tennis gripping tensions.

Summary

The data were subjected to several analyses. First, dif-

TABLE VII. ANALYSIS OF VARIANCE TO DETERMINE DIFFERENCES BETWEEN GROUPS OF PERCEIVED SCORES

	df	SS	MS	F
Between Groups	2	461.13	230.57	
Within Groups	42	5,506.57	131.11	1.759
Total	44	5,967.70		

TABLE VIII. MEANS AND STANDARD DEVIATIONS OF VARIABLE ERROR SCORES

Treatment Group	Varsity	GIPPE	PE
Sample Size	15	15	15
Mean	6.28	5.70	6.72
Standard Deviation	1.74	2.16	2.35

TABLE IX. ANALYSES OF VARIANCE
OF VARIABLE ERROR SCORES

	df	SS	MS	F
Between Groups	2	7.85	3.93	0.8900
Within Groups	42	185.22	4.41	
Total	44	193.0663		

ferences were found among the means and standard deviations of the scores. Physical education majors had a higher perceived mean score while the varsity members had the highest maximum mean score. Day-to-day and trial-to-trial differences were found to be nonsignificant. An intraclass correlation was computed in order to establish reliability. As a result the measurement schedules were considered to be free from systematic error variance. Three independent analyses of variance were computed to determine differences between groups. The F ratio found was nonsignificant. The final analysis of variance was computed to determine if differences existed between variable error scores. Once again, the obtained F ratio was nonsignificant.

Chapter V

DISCUSSION OF RESULTS

The discussion of results reported in Chapter IV are presented in this chapter. Included were the following areas: (1) the practical significance of the investigation, and (2) how the results of the study compare with other studies that have investigated kinesthesis.

Kinesthesis is important to the physical educator when teaching a new skill. This involves an awareness of the movement of the body, or is sometimes referred to as "muscular sense." Several activities are concerned with the ability to grip an implement correctly. Some of these are tennis, golf, and badminton. This ability consistently to exert the same pressure on the apparatus is very important. The purpose of this study was to determine if grip strength differences existed between various skill level tennis players. More research, however, is needed in this area of obtaining optimal grip strength for a sport such as tennis. It would be much more beneficial to the student if the instructor could tell the student to grasp his tennis racket at a particular percentage of his maximum rather than saying "firmly."

Very little research has dealt directly with the problem of consistently reproducing a specific submaximal grip effort. However,

several studies have attempted to establish reliability when measuring kinesthesis, and to compare athletes and nonathletes.

A study related to the present one was conducted by McEachran(38), who measured the ability of male students accurately and consistently to reproduce three submaximal strengths. The subjects both overestimated and underestimated 75 per cent of their maximum strength scores while continually overestimating both 25 and 50 per cent. Reliability was established in the investigation. It was found that those who estimated 25 per cent had an R of 0.9238, while those who estimated 50 per cent of their maximum obtained an R of 0.9005, and those required to estimate 75 per cent had an R of 0.8594. In the present study, similar reliability coefficients were found. The varsity team members had an R of 0.898, GIPPE R = 0.936, and the physical education majors obtained an R of 0.947. Therefore, when comparing the results of this investigation with those of McEachran it might be concluded that females and males are similar in their ability to reproduce consistently a specific submaximal level of gripping force.

In 1957 Slater-Hammel(28) investigated kinesthetic perception of muscular force with muscle potential changes. The subjects were male and female physical education majors, not varsity athletes, and male and female liberal arts majors, also not varsity athletes. Slater-Hammel concluded that all groups tended to reproduce more

than the standard muscular force as represented by 125 microvolt potentials. Therefore he found no differences in reproduction of a muscular force between athletes and nonathletes. The results of the present investigation also show no differences in perceived and maximal grip strengths between athletes (varsity tennis and physical education) and nonathletes (GIPPE).

In further support, Sisley(40) investigated the relationship between kinesthesis and the level of skill of three groups of subjects selected for their ability in basketball, bowling, and tennis. He found that no group scored significantly higher on the kinesthetic battery, and no correlation between skill level and kinesthetic sensitivity. These results, which show no correlation between skill level and kinesthetic sensitivity, seem to accord with the findings of the present investigation which shows no relationship between kinesthetic perception and various tennis skill levels.

Kinesthesis, or the muscular sense, may be one of the least understood yet most important of our senses. Studies have dealt with aspects such as nonathletes and athletes and the reliability of the measures of kinesthesis. Slater-Hammel(28) and McEachran(38) are samples of such studies which also coincide with the results of the present investigation.

Chapter VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to compare the maximal dominant hand grip strength and the perceived grip force used while gripping a tennis racket of female college students with varying tennis backgrounds. These tennis experiences were the varsity team members, physical education majors, and GIPPE students.

The subjects involved in the study were 45 female Ithaca College students. The subjects were classified into three groups according to their tennis experience. They were randomly selected from their respective populations. The testing equipment used was the cable-tensiometer with an orthopedic attachment. Adjustments were made possible by the use of several metal balls which were welded to the tensiometers. The cable-tensiometer was bolted to a wooden supporting structure that was fastened to a metal desk with C-clamps. A stopwatch was used in timing the rest periods.

Standardized directions were read on the first day of testing to every subject. On each of the three consecutive days of data

collection a subject was given three trials gripping a tennis racket at the force used to execute a forehand stroke. A 30-second rest period was given between these trials. The subjects were then required to repeat the same effort five times using the cable-tensiometer with a 30-second rest between trials. Following a one-minute rest each subject was required to exert two maximum grip strength trials with a one-minute rest between trials.

The data analysis began with the computation of the means and standard deviations for each subject, maximum and perceived tennis grip scores. An analysis of variance for trials x days was computed for maximum scores. An intraclass correlation based on appropriate mean scores calculated in the analysis of variance was computed. Finally, to determine differences between groups, three independent analyses of variance were computed.

The major null hypothesis that no significant differences existed in maximal grip strength, perceived grip strength, or the consistency of the perceived grip strengths between the women's varsity team members, physical education majors, and GIPPE participants with tennis experience was accepted. The level for statistical rejection or acceptance of the null hypothesis was the .05 level of significance.

Conclusions

After completing research, and within the limitations of the study, this investigator feels justified in making the following conclusions:

1. Varsity tennis team members, physical education majors, and GIPPE students do not differ in the recorded tension that they perceive is the force required to properly grip a tennis racket during a forehand stroke.

2. Varsity tennis team members, physical education majors, and GIPPE students do not differ in the recorded maximal grip strength scores.

3. College age females have the ability to consistently reproduce a perceived submaximal grip tension.

Recommendations for Further Study

From the results of this investigation, the researcher suggests the following recommendations for further study:

1. A similar study using another activity involving the gripping action, such as golf.

2. A study comparing female athletes and nonathletes as to their ability to reproduce a desired effort.

3. A study comparing female and male athletes' ability to reproduce a desired effort.

4. A study to determine the importance of kinesthesis in an activity which requires a gripping action.

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APPENDIX

APPENDIX A. MEANS OF MAXIMUM AND PERCEIVED SCORES FOR ALL SUBJECTS

	Varsity		Physical Education Majors		GIPPE Students	
	Maximum	Perceived	Maximum	Perceived	Maximum	Perceived
1.	61.93	44.50	70.83	42.23	49.75	39.01
2.	54.58	35.67	52.51	20.97	45.39	40.19
3.	52.11	25.15	40.44	26.08	50.19	27.72
4.	55.19	36.50	48.34	36.40	51.84	22.33
5.	55.40	52.33	40.49	26.45	50.20	25.28
6.	54.20	35.18	50.21	39.45	67.63	27.38
7.	62.33	26.12	56.66	40.99	50.98	31.59
8.	50.22	17.17	39.59	21.92	34.76	15.42
9.	64.41	39.64	63.88	30.62	50.42	28.48
10.	43.33	38.42	62.98	56.72	32.82	14.82
11.	67.28	31.39	66.14	62.15	33.40	10.67
12.	78.33	35.12	46.66	22.72	53.47	42.13
13.	33.90	25.74	79.58	58.89	47.08	27.91
14.	77.49	19.72	38.75	28.50	59.29	43.59
15.	42.43	19.71	57.12	40.13	47.70	41.15