AN EXPERIMENTAL STUDY OF THE VALUE OF A DEVICE DESIGNED TO RESTRICT ELBOW-BEND IN TEACHING TENNIS FOREHAND AND BACKHAND DRIVES

A Dissertation

Presented to

the Faculty of the College of Education

The University of Houston

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

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by

Jewell Gwendolyn Pye

August, 1963

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The purpose of the study was to determine the value of an external device which would eliminate the tendency of beginning tennis players to bend the elbow when learning the forehand and backhand drives. The device was designed and constructed as a cradle-type, posterior elbow brace to hold the elbow in a position of one hundred eighty degrees extension.

Twenty-seven women physical education students served as subjects for the experimental group and twenty-seven women physical education students served as subjects for the control group. All the subjects were students at Sul Ross State College, Alpine, Texas. The only requisite for enrolling in either of the classes was that members had received no previous tennis instruction.

The equating of the experimental group and the control group involved the administration of The Scott Motor Ability Test, The Dyer Backboard Test of Tennis Ability, and The Broer-Miller Forehand and Backhand Drive Test.

The teaching unit for each group consisted of twenty-five hour-long periods of instruction in the tennis forehand and backhand drives. The verbal method of teaching and the demonstration method of teaching were utilized by the

instructor in both groups, and the experimental factor was applied in the experimental group. The experimental group and the control group were compared in terms of achievement and performance following the completion of the teaching unit.

Neither the experimental group, with a critical ratio of .647, nor the control group, with a critical ratio of .704, revealed any significant improvement in performing The Dyer Backboard Test of Tennis Ability. No significant difference existed between the two groups as indicated by a critical ratio of 1.181.

The experimental group, with a critical ratio of 1.924, revealed improvement of minor significance in the performance of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The control group, with a critical ratio of 2.818, revealed significant improvement in the forehand drive phase of the test. No significant difference between the two groups was evidenced by a critical ratio of .562.

The experimental group, with a critical ratio of 8.220, and the control group, with a critical ratio of 4.675, showed significant improvement in the performance of the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. A significant difference in improvement in favor of the experimental group was revealed by a critical ratio of 4.145.

No significant difference between the two groups was revealed by the judges' subjective ratings of form during the execution of the forehand drive, as indicated by a critical ratio of 1.284.

No significant difference between the two groups was revealed by the judges' subjective ratings of form during the execution of the backhand drive, as indicated by a critical ratio of .140.

The apparent value of a device designed to eliminate the tendency of beginning tennis players to bend the elbow in learning the backhand drive, as indicated by the results of this study, seems to warrant (1) further investigation of the worth of the device in learning the backhand drive to include physical education classes in public schools and colleges and universities, and (2) similar studies to determine the value of a movement-restriction device in learning various other activities such as the golf drive and the flutter kick in swimming.

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THE PROBLEM AND ITS SCOPE

The period during the years 1927 to 1952 was an era of transition in the physical education program in America. According to Nixon and Cozens, the transition involved the shifting of emphasis from the formalized physical education program to a newer, informal program.[1] Nixon and Cozens observed that the transition from the formalized program to the informal program has resulted in the discarding of many valuable, specific teaching techniques.[2] Nixon and Cozens stated the informal program, based on natural activities, has left the formulation of teaching techniques to the individual instructor, and as a result, the physical education program has become a natural setting for much poor teaching.[3] Proponents of the informal program have protested the possibility of adaptability of a rigid set of rules governing the functions of teachers.[4]

However, a compilation of specific teaching techniques

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[1]Eugene W. Nixon and Frederick W. Cozens, _An Introduction to Physical Education_ (fourth edition; Philadelphia: W. B. Saunders Company, 1952), p. 177.

[2]_Ibid_.

[3]_Ibid_., p. 178.

[4]_Ibid_.

which might facilitate learning motor skills have been mentioned as possible valuable contributions to the area of teaching.[5] The establishment of specific teaching techniques would necessitate a thorough study of the present techniques used in teaching the various activities, as well as the investigation of any possibilities for the development of new techniques. An analysis of any specific problem confronted by physical educators in teaching the various activities would constitute an initial step in studying the present techniques and in investigating any possibilities for the development of new techniques.

The tendency of beginning tennis players to bend the elbow has been a problem for some physical educators in teaching the forehand and backhand drives. Authorities have expressed various explanations of the problem. Broer advanced the theory that the tendency to bend the elbow may be due to a spatial-judgment problem,[6] while Slater believed the tendency could be partially attributed to muscle imbalance in the upper arm.[7]

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[5] Ibid.

[6] Marion R. Broer, Efficiency of Human Movement (Philadelphia: W. B. Saunders Company, 1960), p. 15.

[7] A. T. Slater, "Action Current Study of Contraction-Movement Relationships in the Tennis Stroke," Research Quarterly, 20: 427, December, 1949.

Statement of the Problem

This study was undertaken to determine the value of a device designed to eliminate the tendency of beginning tennis players to bend the elbow when learning the forehand and backhand drives. The specific purposes of the study were (1) to select a suitable device for restricting elbow-bend, (2) to select the control group and the experimental group, (3) to apply the device designed to restrict elbow-bend to the experimental group, and (4) to compare the two groups in terms of achievement and performance following the completion of the teaching unit.

Need for the Study

A great deal of the research in physical education has been focused on such topics as program, equipment, and administration; conversely, the improvement of teaching methods has received very little attention for several years.[8] Nixon and Cozens, in discussing the need for research in teaching methods, emphasized investigation of specific techniques of teaching the various activities commonly included in the physical education programs. Nixon

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[8]Elwood Craig Davis and Earl L. Wallis, Toward Better Teaching in Physical Education (revised edition; Englewood Cliffs: Prentice-Hall, Inc., 1961), pp. v-vi.

and Cozens also suggested the possibility of formulating a set of specific techniques for each activity included in physical education programs.[9]

An understanding of how learning occurs was recognized as a requisite for research in teaching techniques.[10] The literature, reviewed by the present investigator, concerning the learning processes emphasized the importance of kinesthetic perception or understanding as an essential experience in the acquisition of motor skills. Oberteuffer explained the value of kinesthetic understanding as follows:

> Learning in physical education involves doing and feeling as well as seeing and hearing. . . . Getting the feel of a motor situation is often the crucial element which breaks the 'log jam' of confusion and frustration and sends the learning curve zooming upward in evidence of marked improvement.[11]

The tendency of beginning tennis players to bend the elbow has been a common problem in the tennis teaching-learning situation. Helen I. Driver, noted tennis instructor, listed elbow-bend as a common fault of beginning tennis players in learning the forehand and backhand drives.[12]

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[9]Nixon and Cozens, op. cit., p. 178.

[10]Ibid., p. 171.

[11]Delbert Oberteuffer, Physical Education (New York: Harper and Brothers, 1951), p. 206.

[12]Helen I. Driver, Tennis for Teachers (enlarged edition; Madison 4, Wisconsin: 803 Moygard Rd., Frost Woods 1956), pp. 68, 74.

Paret offered the following explanation concerning the disadvantage of tennis drives characterized by elbow-bend:

> It is practically impossible to make a good stroke when the ball is played from close to the body. . . . The elbow becomes bent and cramped when the ball gets in close to the player's body, and there is little or no power in a stroke made from such a position.[13]

The statements of Driver and Paret indicated to the present writer the feasibility of investigating teaching techniques as a possible means of minimizing the tendency of beginning tennis players to bend the elbow in learning the forehand and backhand drives.

Basic Assumptions

A review of the literature relating to the present study revealed the following basic assumptions:

1. There is a need for research in teaching-techniques for physical education.

2. An understanding of how learning occurs is a requisite for research in teaching-techniques.

3. Kinesthetic perception is an essential experience in learning motor skills.

4. The tendency to bend the elbow is a common fault of beginning tennis players in learning the forehand and

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[13] J. Parmly Paret, Lawn Tennis Lessons for Beginners. (New York: The Macmillan Company, 1916), pp. 21-22.

backhand drives.

Hypothesis

The writer proposed the following hypothesis for the purposes of this study: An external device, designed to restrict elbow-bend, would effect kinesthetic understanding of forehand and backhand drives and facilitate the acquisition of the skills.

Limitations of the Study

Certain limitations were established as relating to the present study. The limitations were as follows:

1. The study was limited to two women's physical education tennis classes, each comprised of twenty-seven beginning tennis players. Members of the classes were enrolled at Sul Ross State College, Alpine, Texas, during the fall semester of the academic year, 1961-62.

2. An external device, designed to restrict elbow-bend, was the experimental factor involved in the study.

3. The critical ratio was the statistical device used in equating the two groups, on the basis of scores obtained from The Scott Motor Ability Test, The Dyer Backboard Test of Tennis Ability, and The Broer-Miller Forehand and Backhand Drive Test.

4. The verbal method and the demonstration method

were utilized in each group, with the external device applied as an added factor in instructing the experimental group.

5. The teaching unit was limited to thirty hours, which included twenty-five hour-long periods for instructional purposes and five periods for evaluation purposes.

6. The critical ratio was the statistical device used in comparing the two groups in terms of achievement and performance following the completion of the teaching unit. The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test were administered at the termination of twenty-five instructional periods. The test scores, and the scores from the same tests given at the beginning of the research, provided the data necessary for comparing achievement between the two groups. A comparison of the two groups of the basis of correct form was determined from the results of judges' ratings. The statistical device used in computing this comparison was the critical ratio.

Definition of Terms

Device designed to restrict elbow-bend. The apparatus was designed as a cradle-type, posterior elbow brace to hold the elbow in a position of one hundred and eighty degrees extension. The brace covered the elbow, the distal one-third of the upper arm, and the proximal one-third of the forearm. The brace was constructed of ST-24 aluminum, felt padding, and an outer covering of plastic similar to leather. The plastic covering was washable and did not absorb perspiration from the arm of the subject. A leather strap was attached to each end of the brace, and the straps were buckled around the arm to hold the brace snugly against the elbow. Soft leather tabs were attached to the straps to serve as protection for the arm. The braces were constructed in three sizes to afford the subject a better fitted device from the standpoint of efficiency of purpose, safety, and comfort. The three sizes of the braces were: (1) nine and one-half inches long by seven inches wide at the proximal end and six inches wide at the distal end; (2) ten and one-half inches long by six inches wide at the proximal end and five and one-half inches wide at the distal end; and (3) nine and one-half inches long by six and one-half inches wide at the proximal end and five and one-half inches wide at the distal end.

Verbal method of teaching. The verbal method of teaching was defined as oral analysis and explanation of the skill by the teacher.

Demonstration method of teaching. The demonstration method of teaching was defined as personal performance by the instructor in presenting a visual analysis of the skill.

Beginning tennis players. Students having no previous instruction in tennis were classified as beginning tennis players.

Method of Procedure

A pilot study pertaining to the problem of elbow-bend among beginning tennis players was conducted at Sul Ross State College during the spring semester of the academic year, 1960-61. The external device, used during the pilot study for restricting elbow-bend, was a thin, rigid, wooden board approximately eight inches long and two inches wide. The device was placed on the inside of the arm at the elbow and was held in place by bands. The pilot study revealed the need for refinement of the device in terms of function and safety. Refinements in the design and construction of the device were contributed by an orthopedic brace specialist in order to ensure maximum safety and efficiency.

Enrollees in two of the women's physical education classes served as subjects for the study. The only requisite for enrolling in either of the classes was that members had received no previous tennis instruction.

The two tennis classes were given one period of instruction and practice in the tennis forehand and backhand drives prior to the administration of the following tests for the purpose of equating the groups: (1) The Scott Motor Ability Test served to determine innate motor ability;

(2) The Dyer Backboard Test of Tennis Ability was used to measure general tennis ability; and (3) The Broer-Miller Forehand and Backhand Drive Test gauged accuracy in placing the ball in various sections of the tennis court. The critical ratio was the statistical device used in equating the two groups, on the basis of scores obtained from the tests.

The experimental group was impartially identified by the toss of a coin. The experimental factor, a device designed to restrict elbow-bend, was applied to the experimental group during twenty-four hour-long periods of instruction in the tennis forehand and backhand drives. The experimental group met from two o'clock to three o'clock on Monday and Wednesday afternoons, and the control group met from two o'clock to three o'clock on Tuesday and Thursday afternoons. The verbal method and the demonstration method of teaching were utilized in both the experimental and the control groups.

At the termination of twenty-five instructional periods, The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test were administered, and members of both groups were rated by a committee of three experts.

The two groups were compared at the conclusions of the teaching unit on the basis of achievement and on the basis of correct stroke execution or form. The average achievement in each group was compared by computing the critical ratio from the achievement data. A comparison of the two groups on the basis of correct stroke execution or form was determined from the results of the subjective ratings. The statistical device used in computing this comparison was the critical ratio.

The data were analyzed and interpreted, and conclusions were drawn from the analyses and interpretations. On the basis of the conclusions, recommendations for further study were made.

Organization of the Remainder of the Study

The remainder of the study has been organized as follows: (1) Chapter II gives the survey of the literature relating to the study; (2) Chapter III consists of a detailed description of the procedures followed in the development of the study; (3) Chapter IV presents and interprets the data collected during the study; and (4) Chapter V presents the summary, conclusions, and recommendations of the study.

CHAPTER II

THE REVIEW OF LITERATURE

The Learning of Motor Skills

The factors involved in motor learning have been revealed as numerous and complex. Physical education teachers have found it imperative to acquire knowledge and understanding of how motor learning occurs in order to realize maximum efficiency in the teaching-learning situation. Physical education instructors have selected teaching techniques which are based on the principles involved in learning motor skills. The present study has been concerned with a specific technique of teaching tennis forehand and backhand drives. The literature reviewed for the present study included articles, published materials, dissertations and theses, bulletins, and excerpts from yearbooks and proceedings of professional organizations. In gleaning the literature, the following questions were considered pertinent to the present study: (1) What is kinesthetic perception and what role does it have in learning motor skills? (2) What is good form, and why is it necessary in the acquisition of motor skills? (3) How do the experts describe good form for executing the tennis forehand and backhand drives with emphasis on the importance of proper leverage; and what thoughts are expressed pertaining to the problem of elbow-bend among beginning tennis players? and (4) What is the role of immobilization or restriction as a therapeutic measure for improving motor performance?

Kinesthesis and Learning Motor Skills

The nature of kinesthetic perception was investigated by the writer and kinesthesis was positively identified as an essential factor in learning motor skills. The literature revealed similarities in the various definitions and connotations of kinesthesis. Franklin Henry referred to kinesthesia as the muscle sense. Henry more precisely defined kinesthesia as an individual's awareness of personal muscular responses.[1]

Weibe described kinesthesis as the position sense and explained the relationship of physical education to kinesthesis by establishing the identity of specific components and functions of kinesthesis. According to Weibe, the components ascribed to kinesthesis were perception of movement, tension or resistance, position, space perception, balance, relaxation, and effort. Such components of kinesthesis were described as familiar concepts in physical education. Weibe listed the functions of kinesthesis as co-ordination of body movements, development of skills, locomotion, posture, body

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[1]Franklin Henry, "Dynamic Kinesthetic Perception and Adjustment," Research Quarterly, 24: 176-77, May, 1953.

control, manipulation, balance, and appreciation of weights and forces. Weibe believed such functions to be important elements in teaching motor skills.[2]

Young described kinesthesis as an innate quality and stated that physical educators generally agreed that kinesthesis contributes to motor educability and learning skills.[3]

Scott also recognized that physical educators believe a relationship exists between kinesthesis and motor performance. However, Scott emphasized the difficulty of attempting to identify varying degrees of kinesthesis. Scott said the definition and identity of kinesthesis is impossible because of a lack of facts. She further stated that research in kinesthetic measurement is a challenging type of investigation but added that such investigation "in analogy is a situation of trying to lift one's self by the boots without even the boot straps to grasp."[4]

Ragsdale stated that motor learning is basically perceptual, especially kinesthetic. He contended the acceptance of motor learning as a strictly mechanical process was completely

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[2]Vernon R. Weibe, "A Study of Kinesthesis," Research Quarterly, 25: 222, May, 1954.

[3]Olive G. Young, "A Study of Kinesthesis in Relation to Selected Movements," Research Quarterly, 16: 277, December, 1945.

[4]M. Gladys Scott, "Measurement of Kinesthesis," Research Quarterly, 26: 324, October, 1955.

erroneous and stressed that kinesthetic perception is fundamental.[5]

Trow recognized the importance of stimuli other than the kinesthetic cue in motor learning but he maintained that, with practice, the kinesthetic cue is largely responsible for the execution of motor skills. Trow directed attention to the fact that the skilled tap dancer does not have to watch his feet, nor the skilled pianist his fingers.[6]

Reference was made in Chapter I to Oberteuffer's reflections on kinesthetic perceptions in motor learning. He also recognized the importance of stimuli other than the kinesthetic cue in learning motor skills. Oberteuffer gave emphasis to the role of kinesthesis through the example of swimmers and dancers. He stated that such learners may be inept, awkward, and confused until they begin to feel what they are doing and there is kinesthetic understanding of the skill as a whole.[7]

The literature concerning the relationship of kines-

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[5]C. E. Ragsdale, "How Children Learn the Motor Types of Activities," Learning and Instruction, Forty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1950), pp. 88-89.

[6]William Clark Trow, Psychology in Teaching and Learning (Boston: Houghton Mifflin Company, 1960), p. 280.

[7]Delbert Oberteuffer, Physical Education (New York: Harper and Brothers, 1951), p. 206.

thesis and motor learning contained frequent references to manual guidance as a teaching technique with some merit as a kinesthetic cue. Manual guidance as a teaching technique was described, the values explained, and the limitations of the technique were recognized.

Kingsley and Garry described manual guidance as follows:

> This procedure involves taking hold of the learner's hands, feet, or whatever part of the body he is to use in the skill to be acquired and pushing them through the desired movements in the proper sequence.[8]

Kingsley and Garry referred to manual guidance as a form of demonstration in teaching, and recognized the value of the learner being able to see personal body members moving in the manner in which he will be asked to perform. The learner also gained the advantage of feeling personal body members in various positions and feeling the movement from one position to another.[9]

Trow recognized manual guidance as the kinesthetic stimulus of "putting the learner through the motions." He conceded that manual guidance cannot be used in teaching the

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[8]Howard L. Kingsley and Ralph Garry, The Nature and Conditions of Learning (second edition; Englewood Cliffs: Prentice-Hall, Inc., 1957), pp. 310-311.

[9]*Ibid*.

vocal skills, or in certain other skills, but established that the technique was useful in speeding up the learning of hand and arm positions such as the grip and swing involved in specific activities.[10]

Ragsdale stated, "Manual guidance is intended primarily to give the learner a kinesthetic perception of the activity..."[11]

Klausmier and Nixon and Cozens upheld the use of manual guidance as a valuable teaching technique.[12, 13] Klausmier included manual guidance as one of the seven principles for improving skill learning. Nixon and Cozens explained that many beginners in an activity find it helpful to have the instructor guide the bodily movements through the correct execution of the skill.

Despite the importance of manual guidance as a kinesthetic cue in motor learning, certain limitations of the technique were revealed. One of the limitations has been the tendency of some students to be disturbed by the personal

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[10]Trow, loc. cit.

[11]Ragsdale, op. cit., pp. 83-84.

[12]Herbert J. Klausmier, Learning and Human Abilities: Educational Psychology (New York: Harper and Brothers, 1961), p. 240.

[13]Eugene W. Nixon and Frederick W. Cozens, An Introduction to Physical Education (fourth edition: Philadelphia: W. B. Saunders Company, 1952), p. 176.

contact involved in manual guidance. The teacher has had to rely on other teaching techniques in such cases.[14] Another limitation of the usefulness of manual guidance as a teaching technique has been the difficulty of application.[15] Manual guidance as a teaching technique has been further limited by the fact that the kinesthesis involved in having an instructor guide a movement cannot be identical with that which comes from the personal execution of the movement.[16]

The various authors placed emphasis on the importance of kinesthesis in learning motor skills. Attention was also directed to the kinesthetic value of manual guidance in teaching motor skills. However, teachers of motor skills were alerted to the importance of other factors involved in motor learning, and to the necessity of a variety of teaching techniques.

Ragsdale, in discussing the learning of motor skills, revealed that some instructors have relied upon one phase of the learning process, as the kinesthetic, and have built a system around it. He called such a system one-sided because:

> We have muscles and use them in motor learning; we have kinesthetic sense organs, eyes, ears, and skin

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[14] *Ibid.*

[15] Ragsdale, *loc. cit.*

[16] Kingsley and Garry, *op. cit.*, p. 311.

> senses and use them all; we have language and use it; we have thinking processes and use them. We collect data about action from all available sources and use them in learning motor activities as fully as our individual intelligence permits. Reflective thinking is the key to learning in this as in all areas.[17]

Ragsdale and Shepard agreed that the techniques of teaching can be classified as methods of communication.[18, 19] Shepard asserted that such methods of communication were endlessly varied and the good teacher would not be restricted to a single form.

Kingsley and Garry left no doubt as to the place of flexibility in teaching techniques:

> Any practice which will help the child realize more clearly what movements he is to make would appear to be psychologically sound if it does not encourage faulty habits.[20]

Correct Form in Learning Motor Skills

The literature revealed conflicting statements regarding the definition of form, or good form. The disagreement ranged from a completely negative statement concerning the

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[17]Ragsdale, *op. cit.*, p. 89.

[18]*Ibid.*, p. 84.

[19]Natalie Marie Shepard, *Foundations and Principles of Physical Education* (New York: The Ronald Press Company, 1960), p. 282.

[20]Kingsley and Garry, *loc. cit.*

definition of form to specific definitions of general good form in motor performance.

Driver and Wills presented negative viewpoints relating to the definition of form.[21, 22] Driver referred to good form in sports activities as a variable quality which defies definition. Wills contended that tennis does not lend itself to dogmatic rules because she believed tennis strokes take on the personality of the player. Wills also theorized that no tennis player can tell anyone exactly how to play.

Paret agreed that good form is an elusive quality which is hard to describe and often harder to adopt. However, he did define good form insofar as it applied to tennis. Paret defined good form to be the manner of using the body which permits the greatest freedom and best ability to stroke the ball successfully.[23]

Kingsley and Garry defined form as the features of a performance which involve bodily adjustment, posture, and ways of grasping the instruments.[24]

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[21]Helen I. Driver, Tennis for Teachers (enlarged edition; Madison 4, Wisconsin: 803 Moygara Rd., Frost Woods, 1956), p. 34

[22]Helen Wills, Tennis (New York: Charles Scribner's Sons, 1929), pp. 16-17.

[23]J. Parmly Paret, Lawn Tennis Lessons for Beginners (New York: The Macmillan Company, 1916), p. 18.

[24]Kingsley and Garry, op. cit., p. 313.

Professional tennis teachers have held meetings and discussed the best ways of teaching pupils, and the best way of producing the basic strokes. There has been general unanimity among the teachers concerning good form in all the basic tennis strokes.[25]

The necessity of good form in motor performances was emphasized by Kingsley and Garry. They conceived of good form as essential for the attainment of the highest possible degree of excellence in performing motor skills. Kingsley and Garry, in referring to the learning of motor skills, believed such skills to be more rapidly developed, with a higher degree of proficiency, if the learner knew and followed certain rules of form developed from the experience of experts. The learner, using poor form, would perform poorly and display little improvement by practice. The effectiveness of the learner's efforts would be greatly increased if good form were mastered during the progress of the instructional and practice sessions.[26]

Paret, in discussing the importance of good form in tennis, referred to the players and some experts who possessed poor form and yet won high honors. Such players have

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[25]Norman H. Patterson, _The Complete Lawn Tennis Player_ (London: Adam and Charles Black, 1948), p. 45.

[26]Kingsley and Garry, _loc. cit._

often been used as models because it was thought the success vindicated the methods. Paret called such reasoning a fallacy in that the successful player with poor form may have certain physical or mental qualities lacking in the average player.[27]

Although Driver was of the opinion that good form defies definition, she emphasized the importance of the principles of good form. In referring to beginning tennis instructions she stated, "The concentration is on the principles of good form with expectations of increased accuracy and speed as the student masters the stroke."[28] Driver also conceived the only way a beginning tennis player could develop good strokes to be through the continuous practice of the principles of good form.[29]

Learning Tennis Drives and the Problem of Elbow-bend

The writer deemed necessary an extensive investigation of the literature relating to tennis instruction. A high level of agreement concerning proper stroke execution was revealed within the writings of noted tennis players,

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[27] Paret, *loc. cit.*

[28] Driver, *op. cit.*, p. 35.

[29] *Ibid.*, p. 37.

professional coaches and instructors, and the experts in kinesiology. The noticeable differences of opinions related to the desirability of a straight arm or a slightly-bent elbow when executing the drives. The professional coaches, instructors, and players were not in complete agreement in regard to the most effective amount of arm extension; however, the kinesiology experts presented scientific evidence favoring full arm extension for maximum efficiency in producing forehand and backhand drives.

The authorities were agreed that excessive elbow-bend has been a common problem for beginning tennis players, and maximum efficiency of the drives was lost as a result. Some of the authorities discussed possible causes to which the problem of elbow-bend might be attributed.

The Forehand Drive. The analysis of the forehand drive, as compiled from the literature, was described for the right-handed individual. Driver advocated the Eastern forehand grip in analyzing the forehand drive. The body should be at right angles to the net with the right foot and shoulder away from the net. The feet should be about eighteen inches apart, the knees slightly flexed, and the weight resting on the balls of the feet. The racket should be swung back in line with the side of the body. The straight backswing, rather than the circular backswing, was advocated for beginning tennis players. The racket head should be held slightly above the wrist and a short pause should occur between the backswing and the beginning of the forward swing. The racket is swung forward and outward to meet the ball. The face of the racket should be flat upon impact with the ball and the body weight should shift from the right foot to the left foot as the forward swing is executed. The trunk should rotate forward with the stroke and the right shoulder should point in the direction of the ball flight on the follow-through. The racket should follow the ball forward as far as possible during the follow-through to insure proper direction of the ball. The height of the follow-through should not be above the shoulders and the arm may be allowed to rotate inward to produce a slightly closed racket face at the end of the follow-through. Driver advised that beginners should hit the ball as it descends from the bounce and the easiest height from which to hit the ball is from knee-high to the waist.[30] According to Scott, as the backswing begins the weight is supported on the rear leg with the knee slightly relaxed. The arm moves the racket back in a somewhat flattened arc at arm's length from the body. Such a backswing enables the player to drive from directly behind the ball and also affords a longer arc for acceleration. The forward drive is begun with a gradual transfer of weight from the rear foot

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[30] Ibid., pp. 62-66.

and the racket is swung from the shoulder as a straight extension of the arm. Such a forward swing provides a long level with the possibility of speed at its extremity. The speed is made possible by strong contractions of the shoulder muscles. Scott stated such a stroke was more powerful than one coming principally from the elbow because of the difference in the length of levers. The wrist prevents the head of the racket from hanging and helps to improve placement of the ball. Scott asserted that with proper transfer of weight during the drive the lever is really the whole body, rotating at the ground. She described the follow-through as a continuation of the forward swing, but with a decreasing amount of force applied.[31]

Patterson believed the forehand drive most easily executed involved the flat horizontal hit. He said the racket should be swung well back, not too fast, and then brought forward with increasing speed and the elbow and wrist locked. Patterson also described the forehand drive as "a stroke played with the body and balance of weight, and with the arm and racket used as a lever only."[32]

Broer and Wells commented on leverage in striking an

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[31] M. Gladys Scott, _Analysis of Human Motion_ (New York: Appleton-Century-Crafts, Inc., 1942), p. 265.

[32] Patterson, _op_. _cit_., p. 58.

object.[33, 34] Broer described the racket as an extension of the arm lever. Wells stated that the extended arm increased the length of the lever and provided greater speed to the racket head. Wells, in discussing the value of increased leverage, asserted that a lever, such as a tennis racket, did not preserve the strength of the user but did increase the range and speed of motion of the user. She said a person striking a ball with a racket can impart more speed to the ball and send it a greater distance than if the ball were hit with the hand. The greater speed and distance were attributed to the fact that the racket head traveled a greater distance than did the hand alone.

Proponents of the theory favoring the slightly-bent elbow during the forehand drive included notable tennis players Kramer, Jacobs, Randle and Hillas, and Sedgman.[35,36,37,38]

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[33]Marion R. Broer, Efficiency of Human Movement (Philadelphia: W. B. Saunders Company, 1960), p. 246.

[34]Katharine F. Wells, Kinesiology (Philadelphia: W. B. Saunders Company, 1960), pp. 280, 434.

[35]Jack Kramer, How to Win at Tennis (New York: Prentice-Hall, Inc., 1949), p. 31.

[36]Helen Hull Jacobs, Tennis (New York: A. S. Barnes and Company, 1941), p. 11.

[37]Dorothy Davies Randle and Marjorie Hillas, Tennis Organized for Group Instruction (New York: A. S. Barnes and Company, 1932), p. 13.

[38]Frank Sedgman, Winning Tennis (New York: Prentice-Hall, Inc., 1954), p. 20.

Jacobs also advised players to keep the eyes on the ball and stated the ball should be hit when just ahead of the left hip.

The Backhand Drive. Driver defined the backhand drive as the stroke used to hit the balls which bounce to the left side of the body. She advocated the use of the Eastern grip in executing the stroke. The wrist should hold the racket head higher than the wrist throughout the stroke. The body should be at right angles to the net with the right foot toward the net and the left foot away from the net. Body rotation away from the net is essential during the backswing to insure a long backswing. The weight should be shifted to the left foot during the backswing and transferred to the right foot during the forward swing. During the backswing, the racket should be drawn back behind the left hip no higher than the position of the ball to be hit. Driver said the straight backswing, rather than the circular backswing, was preferable for beginning tennis players. Shoulder action should begin the forward swing and the body should rotate toward the net with the swing of the racket. As the ball is hit, the arm and racket should form one long lever. The follow-through should be above the shoulder to lift the ball over the net and the racket should reach out in the direction of the ball flight. Driver said there may be outward rotation of the arm to close the racket face slightly on the follow-through. She advised that waist high balls are the easiest to hit and beginners should hit the ball as it descends from the bounce.[39]

Scott, in discussing the backhand drive, related that many players have difficulty in attaining sufficient backswing because of the arm crossing the body. She contended the sweeping arm into abduction seemed easier than the arm swing forward across the body. Scott asserted such a full arm swing from the shoulder was more apt to be used and greater power resulted.[40]

Beginning Tennis Players and the Problem of Elbow-bend. The literature relating to the forehand and backhand tennis drives revealed the extent of the tendency of beginning tennis players to bend the elbow.

P. A. Vaile implied the tendency to bend the elbow to be one of the greatest faults of nearly all beginners. Specifically, he stated that getting too close to the ball was the error.[41]

Driver presented a more definite explanation as she listed elbow-action swing as one of the common errors by beginning tennis players in learning the forehand and backhand

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[39]Driver, *op. cit.*, pp. 70-73.

[40]Scott, *Analysis of Human Motion*, p. 267.

[41]P. A. Vaile, *Modern Tennis* (New York: Funk and Wagnalls Company, 1915), p. 29.

drives. She defined elbow-action swing as "a downward swing with leverage applied more from the elbow joint than from the shoulder joint."[42]

Powdermaker, in listing the common errors by beginning tennis players, referred to the problem as getting too close to the ball. However, she cautioned the players to avoid bending the elbow but to swing from the shoulder.[43]

Paret, in summing up errors of beginning tennis players indicated two principal faults: (1) getting too close to the ball and, (2) bending the elbow during the stroke. He was very emphatic in advising beginning tennis players to keep away from the ball in order to avoid bending the elbow.[44]

Harmon, in discussing the backhand drives, asserted that the common fault among most poor players was the bent elbow which resulted from standing too close to the ball. He instructed players to concentrate on the elbow and keep it straight.[45]

Sedgman referred to the problem of elbow-bend during the backhand drive as a "punching or poking motion". He

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[42]Driver, _op_. _cit_., pp. 31, 102, 104.

[43]Therese Powdermaker, _Physical Education Play Activities for Girls in Junior and Senior High Schools_ (New York: A. S. Barnes and Company, 1938), pp. 314,316.

[44]Paret, _op_. _cit_., pp. 21, 24, 31.

[45]Bob Harmon and Keith Monroe, _Use Your Head in Tennis_ (New York: Thomas Y. Crowell Company, 1950), pp. 55-56.

said the fault was common among players who lacked confidence and wrongly imagined that an abbreviated swing resulted in better control of the ball.[46]

Broer, in discussing the bent elbow of beginning tennis players, explained that the fault may be due to a spatial judgment problem. The individual has, through the years, formed a concept of the distance he can reach; and, familiar with the length of his arm, he can quickly determine how near to approach an object he wishes to strike with his hand. Broer believed when the individual was given a tennis racket which lengthened the reach approximately twenty-four inches, the habit of a lifetime was too great and the individual approached the ball at the normal distance he could reach with his hand. Broer said the individual, upon finding himself too near the ball, drew the elbow toward the body to shorten the reach.[47]

Slater, in a study entitled "Action Current Study of Contraction-Movement Relationships in the Tennis Stroke," discovered strong contractions of the triceps during the forehand drive. Slater believed the contractions of the triceps contributed to the extension of the elbow and expressed the possibility that the action involved more than simple

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[46]Sedgman, op. cit., p. 28.

[47]Broer, op. cit., p. 15.

extension. He presented the theory that the actions of the triceps might represent a phenomenon where the contraction of the biceps was so strong as to bend the elbow as well as swing the arm forward. Slater, on the basis of such theory, believed the strong contractions of the triceps served the dual purpose of permitting the biceps to function at maximum strength, and of holding the elbow straight as the activity required. The amount of triceps contraction depended upon the amount of resistance which counteracted the flexing action of the biceps. Strong triceps contractions appeared when the resistance was not sufficient to overcome the flexion of the biceps. A laxity or lessening of triceps contractions could not overcome the strong biceps contractions and, therefore, the elbow would be drawn into a bent position.[48]

The literature revealed that the primary disadvantage of driving a tennis ball with the elbow bent was the loss of power due to the shortened lever.

The shortening of the lever, when a player was too near the ball, has been called accommodation. Driver believed accommodation should not be encouraged for the beginning tennis player. She contended that accommodation leads to faulty habits contrary to good form. Driver said the

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[48]A. T. Slater, "Action Current Study of Contraction-Movement Relationships in the Tennis Stroke," Research Quarterly, 20: 427, December, 1949.

beginner should practice the correct swing even if the ball were missed or hit out of the court. She further stated that very few beginners ever developed into good tennis players, if allowed to continue using a stroke characterized by elbow-action and the ball position in front of the head and shoulders.[49]

Immobilization and Restriction as Methods of Facilitating Motor Performance

The literature yielded some references relating to the role of immobilization in the area of rehabilitation. Some types of immobilization apparatus and the uses or functions of such apparatus were discussed.

Rusk stated that braces, self-help devices, and splints are commonly used terms in the field of rehabilitation. He described splints and braces as devices used to control the action of specific joints to prevent motion, to increase motion, and to increase muscle power. Such devices were said to be individually prescribed.

Rusk described two types of splints. He referred to static splints as those which serve to support the involved segment, to prevent contracture, and to protect the injured part. The other type of splints included those which serve

[49]Driver, _op_. _cit_., pp. 35-37.

to encourage therapeutic exercise and functional use.[50]

Grice used the terms static splinting and active splinting. He believed active splinting assisting in the functional pattern was the preferable type. However, Grice stated that both types had specific purposes.[51]

Kessler, in discussing the rehabilitation of cerebral palsy patients, stated:

> Braces are chiefly used, not for support, but as additional teaching devices in developing accuracy of joint function or by means of locking devices to allow emphasis to be placed on one joint to develop its function alone when desired.[52]

Kessler used as an example the patient with an improperly learned gait. The gait developed was characterized by the flexed knees and insufficient hip function. He explained that braces could be used to immobilize the knees in order to encourage hip function. Once hip function has been corrected, the knee action can again be introduced. Kessler believed braces to be of great value in assisting the correction of faulty habits of muscular functions.[53]

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[50]Howard A. Rusk, Rehabilitation Medicine (St. Louis: C. V. Mosby Company, 1958), pp. 177, 187.

[51]David S. Grice, "Rehabilitation Therapy in Poliomyelitis," Rehabilitation of the Handicapped: A Survey of Means and Methods, William H. Soden, editor (New York: The Ronald Press Company, 1949), p. 163.

[52]Henry H. Kessler (in collaboration with other authors), The Principles and Practices of Rehabilitation (Philadelphia: Lea and Febiger, 1950), p. 295.

[53]Ibid.

Grice, in discussing the rehabilitation of poliomyelitis patients, exposed muscle imbalance as a causative factor for deformity. He explained that when the patient with weak dorsiflexors of the foot and a normal gastrocnemius begins to walk, the gastrocnemius will actively function with inadequate opposition by the reciprocal muscles of dorsiflexion. The dorsiflexors may briefly work effectively in lifting the foot against gravity and in the absence of contracture. However, as the muscles become fatigued and are unable to dorsiflex the foot, the patient will develop an equinus gait later resulting in deformity. Grice stated that the use of braces and crutches have proven to be of utmost importance in the rehabilitation of such cases which resulted from muscle imbalance. He emphasized the wide use of apparatus in preventing deformity and allowing an increase in the activity of partially paralyzed muscles.[54]

Summary

Chapter II was a discussion of the opinions and facts discovered by the writer through an investigation of the literature pertaining to (1) the role of kinesthetic perception in learning motor skills, (2) the importance of good form in motor performance, (3) a description of correct form conducive

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[54]Grice, op. cit., p. 162-63.

to maximum efficiency in executing tennis drives, and (4) the role of immobilization as a therapeutic measure for the improvement of motor performance.

A detailed discussion of the procedures followed in the development of the current study has been presented in Chapter III.

CHAPTER III

PROCEDURES USED IN THE STUDY

A detailed description and discussion of the procedures involved in the development of the present study are presented in this chapter. The procedures deemed essential for the successful completion of the present study evolved from the following specific purposes as stated in Chapter I: (1) to select a suitable device for restricting elbow-bend; (2) to select the control group and the experimental group; (3) to apply the device designed to restrict elbow-bend to the experimental group; and (4) to compare the groups in terms of achievement and performance following the completion of the teaching unit. The procedures involved in the development of the study are discussed under the following headings: Preliminary Steps, The Selection of the Device to Restrict Elbow-bend, The Selection of the Subjects and Equating the Groups for the Study, the Teaching Unit, The Final Tests and the Judges' Ratings for Comparing the Groups, and The Statistical Treatment of the Data for Comparing the Groups.

Preliminary Steps

An intensive review of the literature pertaining to the teaching and learning of motor skills was considered imperative in approaching the problem. A comprehensive investigation concerning the correct form in executing motor skills, techniques of teaching motor skills, and problems relating to the acquisition of motor skills, served to orient the writer in the general area of physical education instruction. More specifically, the review of the literature included the investigation of the teaching and learning of the tennis forehand and backhand drives.

Permission to conduct a pilot study pertaining to the present study was received from the Dean of the College at Sul Ross State College, Alpine, Texas. The pilot study was conducted at Sul Ross State College during the spring semester of the academic year, 1960-61. The pilot study revealed the need for (1) a more adequate sampling of subjects, (2) a more qualified committee of judges for rating the performance of the subjects, (3) a more valid method of equating the experimental group and the control group, and (4) the refinement of the device designed to restrict elbow-bend, in terms of function and safety.

The Dean of the College at Sul Ross State College granted permission to conduct the present study during the fall semester of the academic year, 1961-62.

The Selection of the Device to Restrict Elbow-Bend

An orthopedic brace specialist was consulted concerning the need for a safe, efficient device to restrict elbow-bend. The orthopedic brace specialist designed and constructed twenty such devices in the form of static braces. The braces were constructed in three sizes, and the variable sizes enabled the subjects to be fitted more accurately with the static braces. A detailed description of the braces was presented in Chapter I.

The Selection of the Subjects and Equating the Groups for the Study

Each woman student wishing to enroll in a physical education class during the fall semester was directed to the writer for scheduling such classes. Each subject was interrogated by the writer in regard to any past experience in organized tennis classes. Women students with no previous tennis instruction were enrolled in the beginning tennis classes provided no conflict existed in the schedule of the subjects. Women students with previous tennis experience were referred to another physical education instructor for registration in one of the various other service courses offered.

A total of fifty-seven women students were registered for the beginning tennis classes. Twenty-nine students were enrolled in Section I and this class met from two o'clock to three o'clock on Mondays and Wednesdays during the semester. Two members of the class dropped the course early in the semester and were not included in the present study. Twenty-eight students were enrolled in Section II and this class met from two o'clock to three o'clock on Tuesdays and Thursdays during the semester. One member of the class dropped the course after four class meetings and was not included in the present study. Each section included twenty-seven women following the withdrawal of the three students. Section I was labeled the experimental group as determined by an impartial toss of a coin. Section II served as the control group for the study.

The equating of the experimental group and the control group was necessary before the teaching unit began. Each class was given one period of instruction and practice in the tennis forehand and backhand drives prior to the administration of the following tests for the purpose of equating the groups: (1) The Scott Motor Ability Test served to determine innate motor ability; (2) The Dyer Backboard Test of Tennis Ability measured general tennis ability; and (3) The Broer-Miller Forehand and Backhand Drive Test gauged accuracy in placing the ball in various sections of the tennis court.

The Scott Motor Ability Test and The Dyer Backboard Test of Tennis Ability were administered during the second class meeting of each group, and The Broer-Miller Forehand and Backhand Drive Test was administered during the third class meeting of each group.

The Scott Motor Ability Test.[1] The test battery included the obstacle race, the standing broad jump, and the basketball throw for distance. The obstacle race and the standing broad jump were administered in the gymnasium, and the basketball throw for distance was administered outside the gymnasium on a large parking lot. Women physical education majors assisted in preparing the test areas and assisted in administering the test. The test was administered during the second class meeting of the experimental group and during the second class meeting of the control group. Subjects ran the obstacle race, proceeded to the broad jump area, then were directed outside for the basketball throw for distance. Subjects were tested in alphabetical order.

The equipment needed for the obstacle race included three jump standards, a cross bar at least six feet long, and lines on the floor as illustrated in Figure 1, page 41. The space required for the obstacle race was an area fifty-five

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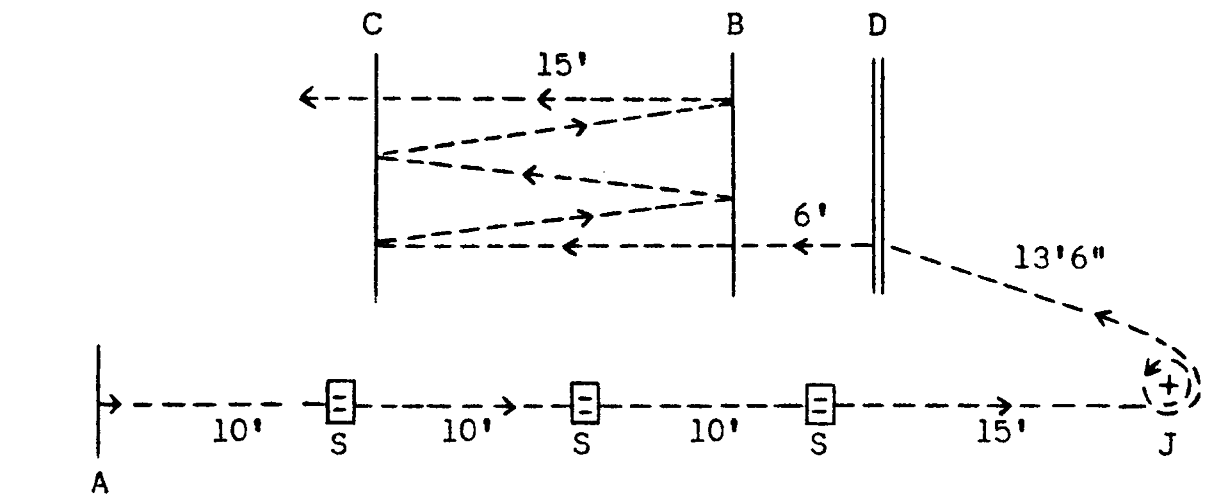
[1]M. Gladys Scott and Esther French, Evaluation in Physical Education (St. Louis: C. V. Mosby Company, 1950), pp. 193-97.



A - Starting Line
B - Line for Shuttle
C - Finish Line
D - Cross Bar (18" high)
J - Jump Standard
S - Spot on Floor (12" x 18")
---- - Path of Runner

Distance from end of cross-bar to line of inner sides of spots, 4 feet, 4 inches.

FIGURE 1

FLOOR MARKINGS FOR OBSTACLE RACE
OF SCOTT MOTOR ABILITY TEST*

*<u>Ibid</u>., p. 194.

feet long and twelve feet wide. The obstacle course consisted of a starting line six feet long, followed at intervals of ten feet by three rectangular boxes drawn on the floor. The rectangular boxes were eighteen inches long and twelve inches wide. A jump standard was placed fifteen feet beyond the third rectangular box and on a straight path from the starting line. Two other jump standards, supporting a cross bar eighteen inches high, were placed at a point thirteen feet and six inches from the first standard, with the line of direction reversing at a slight angle and moving back toward the starting line. The distance of the inner jump standard supporting the cross bar from the inner end of the rectangular boxes was four feet and four inches. A line six feet long was drawn on the floor six feet beyond the cross bar, and the finish line, also six feet long, was drawn on the floor twenty-one feet beyond the cross bar.

The subjects were given instructions and directions concerning the test before the obstacle race was begun. The subject started in a supine position on the floor with the feet nearest the starting line. On the signal, ready, go, the subject arose and started running toward the lone jump standard. The subject stepped on each of the three rectangular boxes with both feet while running toward the jump standard. The subject circled the jump standard twice and proceeded toward the cross bar. The subject crawled under the cross bar and ran toward the finish line. The subject reversed directions at the finish line and shuttled twice between the finish line and the line drawn six feet beyond the cross bar. The obstacle race was completed when the subject reached the finish line the third time. The obstacle race was scored by recording the number of seconds, to the nearest one-tenth of a second, required to run the course.

The standing broad jump required mats at least seven feet and six inches long, and a solid board at least two feet long. The board was placed against the wall to prevent slipping. The mat was marked in two inch intervals to simplify the measurement of the jumps.

The subjects were given instructions and directions concerning the test before beginning the broad jump. The subject stood at the starting point, and the jump was made from both feet simultaneously and as far forward as possible. The subject was allowed three jumps, and the longest jump was recorded. The score was the distance from the starting line to the nearest heel, or to the nearest part of the body if the balance were lost. A student assistant recorded the scores and observed any violations at the starting line. Two other assistants measured the distances jumped and reported the scores to the recorder.

The basketball throw for distance required an area approximately eighty feet long and twenty feet wide. A throwing line, marked eight feet from one end of the area, was followed by parallel lines every five feet beginning fifteen feet in front of the throwing line. Three regulation leather basketballs were used for the test.

The subjects were given instructions and directions concerning the basketball throw for distance before beginning the test. The subject made the throw from behind the starting line and was not allowed to step on or across the line when throwing. The subject was allowed to throw the basketball using any type of throw. The subject was asked to execute three consecutive throws. The longest throw was scored, and the score was the distance from the throwing line to the spot where the ball touched the ground. A student assistant stood at the starting line and observed any violations and recorded the scores. Two other student assistants measured the distances of the throws and called out the scores to the recorder. One other assistant retrieved the balls already thrown. The assistant rolled the balls on the ground to the subjects waiting to be tested.

The Dyer Backboard Test of Tennis Ability.[2] The two end walls of the gymnasium were marked and used as test areas for the administration of The Dyer Backboard Test of Tennis Ability. The test required a wall area of approximately ten

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[2]H. Harrison Clarke, Application of Measurement to Health and Physical Education (third edition; Englewood Cliffs: Prentice-Hall, Inc., 1959), pp. 345-46.

feet in height and fifteen feet in width. A line three inches wide, representing the net, was drawn across the wall test area with the top of the line measuring three feet from the floor. A restraining line was drawn on the floor five feet from the base of the wall. A box, approximately twelve inches long, nine inches wide, and three inches deep was placed on the floor at the junction of the restraining line and the left side-line for the right-handed subjects. The box was placed on the floor at the junction of the restraining line and the right side-line for left-handed subjects. The box contained extra balls to be used by the subjects during the test.

The test instructions were explained to the subjects before the test began. The subject was provided with two tennis balls and a racket. The subject stood behind the restraining line and started the test on a signal given by the student assistant holding the stop watch. The subject dropped a ball and after one bounce, played the ball against the wall as rapidly as possible for thirty seconds. The ball did not have to bounce before being played with the exception of the start of the test or when a new ball was put into play. The subject was permitted to use any stroke or combination of strokes, but all balls had to be played from behind the restraining line. The subject was allowed to cross the restraining line to retrieve balls, but any hits made while in such a position were not scored. The subject used the second ball, of the two balls supplied at the beginning of the test, when the first ball was not playable. Thereafter, the subject used additional balls from the box when necessary. The subject was awarded one point for each ball striking the wall on or above the net line before thirty seconds had ended. Three trials were given each subject, and the final score represented the sum of the points on the three trials. All the subjects at each test area completed the first trials before the second trials began. The third trials followed the completion of the second trials. Student assistants conducted The Dyer Backboard Test of Tennis Ability as follows: (1) number one counted the number of balls striking the wall on or above the net line; (2) number two checked the number of violations at the restraining line; (3) number three recorded the scores; and (4) number four operated the stop watch and signaled the subject to begin the test and to stop at the end of thirty seconds. Subjects waiting to be tested retrieved the balls already hit. The scores were recorded on individual forms as illustrated in the Appendix.

The Broer-Miller Forehand and Backhand Drive Test.[3] The Broer-Miller Forehand and Backhand Drive Test required the use of two tennis courts, with a regulation tennis net on

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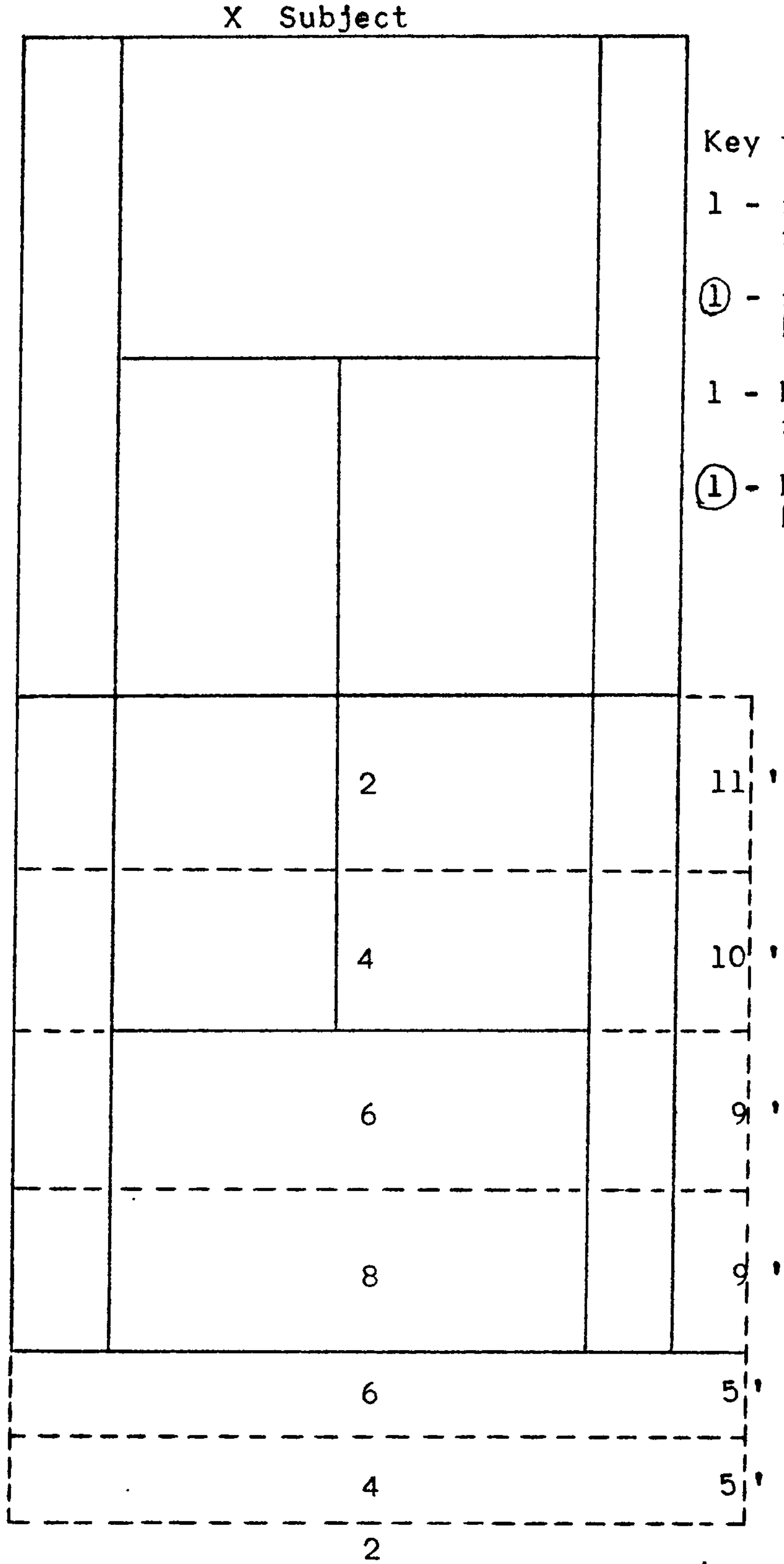
[3] *Ibid.*, pp. 347-48.

each court. A rope was stretched four feet above each net. The ropes were attached to boards, two inches by four inches, and the boards, attached to the net posts, extended from the ground to five feet above the top of the net. Special court markings, as illustrated in Figure 2, page 48, were necessary. Masking tape was used for the special court markings. One court was used for the forehand drive test, and the second court served as the test area for the backhand drive. The subject, upon completing the forehand drive test, picked up the score sheet from the recorder and proceeded to the second court for the backhand drive test. Each subject was allowed fourteen trials for the forehand drive test and fourteen trials for the backhand drive test. A box containing an adequate number of balls was placed near the subject being tested.

The subjects were given instructions concerning The Broer-Miller Forehand and Backhand Drive Test before the tests began. The subject stood behind the baseline, dropped the ball, then hit the ball after one bounce. Each ball scored two, four, six, or eight points, depending upon the court area where the ball landed. Any ball passing over the rope scored one-half the value of the court area where the ball landed. A trial was counted if the subject missed the ball in attempting to hit the ball. "Let" balls were replayed. Any balls hit outside the scoring areas marked on the court did not score points. Student assistants conducted The Broer-Miller



Key to Scoring

1 - forehand, full value

1 - forehand, half-value

1 - backhand, full value

1 - backhand, half-value

Court Markings for Forehand-Backhand Drive Test (Broer-Miller)

FIGURE 2

FORM USED IN RECORDING SCORES FOR THE BROER-MILLER TEST

Forehand and Backhand Drive Test. The scorers for the test assumed positions allowing full vision of the scoring areas. Another student assistant was in a position to watch the net and the rope and informed the scorer when balls passed over the rope and when "let" balls occurred. A student assistant counted and presented the balls to the subject and informed the subject when fourteen balls had been hit. Two other assistants retrieved balls already hit. Scores were recorded on individual forms as shown in Figure 2.

McCloy and Young observed that The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test were the two tennis tests having been formulated scientifically and subjected to rigorous scientific validation.[4]

The Comparison of Test Scores. The scores made by the subjects on The Scott Motor Ability Test, The Dyer Backboard Test of Tennis Ability, and The Broer-Miller Forehand and Backhand Drive Test were treated statistically to equate the experimental group and the control group. The statistical device for comparing the two groups was the critical ratio.

The means, the standard error of the means, the mean

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[4]Charles Harold McCloy and Norma Dorothy Young, Tests and Measurements in Health and Physical Education (third edition; New York: Appleton-Century-Crofts, Inc., 1954), p. 252.

differences, the standard error of the mean differences, and the critical ratios were calculated for the scores of the three tests. The business machines of the Business Administration Department at Sul Ross State College, Alpine, Texas, were used to compute the statistics.

The formula employed in computing the mean (M) was as follows:[5]

$$\text{Mean} = \text{G.A.} + \left(\frac{\Sigma fd}{N} \times \text{SI}\right)$$

The standard deviation (σ) was calculated by using the formula:[6]

$$\sigma = \sqrt{\frac{\Sigma fd^2}{N} - \left(\frac{\Sigma fd}{N}\right)^2} \times \text{SI}$$

The standard error of the mean (σM) was determined by using the formula:[7]

$$\sigma M = \frac{\sigma}{\sqrt{N-1}}$$

The mean difference (M diff) and the standard error of the mean difference (σ diff) were calculated by employing the

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[5] Clarke, _op. cit._, p. 429.

[6] _Ibid._, p. 435.

[7] Benton J. Underwood, Carl P. Duncan, Janet A. Taylor, and John W. Cotton, _Elementary Statistics_ (New York: Appleton-Century-Crofts, Inc., 1954), p. 110.

following formulas:[8]

$$M \text{ diff} = M_1 - M_2$$

$$\sigma \text{ diff} = \sqrt{M_1{}^2 + M_2{}^2}$$

The critical ratio (cr or t) was determined according to the formula:[9]

$$t = \frac{M^1 - M^2}{\sigma \text{ diff}}$$

The raw scores for The Scott Motor Ability Test were converted to T-scores. The T-scores of each subject for the obstacle race, the standing broad jump, and the basketball throw for distance were added and divided by three to arrive at the battery score for each individual subject. The T-scales for Motor Ability Tests for College Women, constructed for The Scott Motor Ability Battery, were used to compute the battery scores of the subjects.[10]

The data from The Scott Motor Ability Battery were treated statistically in comparing the native motor ability of the experimental group with the native motor ability of

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[8]Ibid., p. 125.

[9]Ibid., p. 127.

[10]Scott and French, op. cit., pp. 203-204.

the control group. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio for The Scott Motor Ability Battery scores of the experimental group and the control group are shown in Table I, page 53. The mean score of the experimental group was 50.351 as compared to the 52.684 of the control group. The standard error of the mean score of the experimental group was 1.015, and the standard error of the mean score of the control group was 1.443. The mean score of the experimental group was revealed to be somewhat more accurate than the mean score of the control group, but both means were shown to be reliable by the standard errors of the two means. The mean difference was 2.333, and the standard error of the mean difference was 1.788. Any significance of the mean difference and the standard error of this mean difference was revealed by computing the critical ratio. The critical ratio calculated from the scores on The Scott Motor Ability Battery was 1.304, and, as a result, the null hypothesis could not be rejected at the ten per cent level of confidence. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.[11] The experimental group and the control group were regarded to

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[11]Allen L. Edwards, Statistical Methods for the Behavioral Sciences (New York: Rinehart and Company, Inc., 1958), p. 501.

TABLE I

SCOTT MOTOR ABILITY TEST RESULTS FOR EQUATING EXPERIMENTAL AND CONTROL GROUPS SHOWING THE MEANS, STANDARD ERROR OF THE MEANS, MEAN DIFFERENCE, STANDARD ERROR OF THE MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ M	M diff	σ M diff	cr
Experi-mental N = 27	50.351	1.015	2.333	1.788	1.304*
Control N = 27	52.684	1.443			

*Not significant at the .1 level of confidence.

be satisfactorily similar in native motor ability on the basis of the critical ratio computed from the data obtained from the scores of The Scott Motor Ability Test.

The total points scored by the subjects, during the three trials of The Dyer Backboard Test of Tennis Ability, were treated statistically in order to compare the general tennis ability of the experimental group with the general tennis ability of the control group. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio for The Dyer Backboard Test of Tennis Ability of the experimental group and the control group are given in Table II, page 55. The mean score of the experimental group was 44.074, and the mean score of the control group was 46.444. The standard error of the mean score of the experimental group was 2.489, and the standard error of the mean score of the control group was 3.167. The standard error of the means revealed the means to be reliable, although the mean score of the experimental group was somewhat more accurate than was the mean score of the control group. The difference in the two mean scores was 2.370, and the standard error of the mean difference was 4.028. Any significance of the mean difference and the standard error of the mean difference was determined by computing the critical ratio. The critical ratio calculated from the scores on The Dyer Backboard Test of Tennis Ability

TABLE II

RESULTS OF DYER BACKBOARD TEST OF TENNIS ABILITY FOR EQUATING EXPERIMENTAL AND CONTROL GROUPS, SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental N = 27	44.074	2.489	2.370	4.028	.588*
Control N = 27	46.444	3.167			

* Not significant at the .1 level of confidence.

was .588, and as a result, the null hypothesis could not be rejected at the ten per cent level of confidence. A critical ratio of 2.008 was necessary to reject the null hypothesis at the five per cent level of confidence.[12] The experimental group and the control group were regarded as satisfactorily alike in general tennis ability on the basis of the critical ratio computed from the data obtained from the scores of The Dyer Backboard Test of Tennis Ability.

The points scored by the subjects when executing the forehand drive during The Broer-Miller Forehand and Backhand Drive Test were subjected to statistical treatment in order to compare the ability of the experimental group to place the ball in the tennis court with the ability of the control group to place the ball in the tennis court. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio for the forehand drive of The Broer-Miller Forehand and Backhand Drive Tests are given in Table III, page 57. The mean score of the experimental group was 31.851, and the mean score of the control group was 26.649. The standard error of the mean score of the experimental group was 2.838, and the standard error of the mean score of the control group was 1.811. The mean score of the experimental group and the mean score of

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[12] *Ibid*.

TABLE III

BROER-MILLER FOREHAND DRIVE TEST RESULTS FOR EQUATING EXPERIMENTAL AND CONTROL GROUPS, SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ M	M diff	σ M diff	cr
Experimental N = 27	31.851	2.838	5.202	3.366	1.545*
Control N = 27	26.649	1.811			

* Not significant at the .1 level of confidence.

the control group were shown to be reliable; however, the mean score of the control group was revealed to be more accurate than the mean score of the experimental group. The difference between the two means was 5.202, and the standard error of the mean difference was 3.666. No important significance was afforded the mean difference and the standard error of the mean difference as substantiated by a critical ratio of 1.545. The null hypothesis could not be rejected at the ten per cent level of confidence and a critical ratio of 2.008 was needed to reject the null hypothesis at the five per cent level of confidence.[13] The critical ratio proved the experimental group and the control group to be suitably alike in ability to place the ball in the tennis court when using the forehand drive.

The scores amassed by the subjects during the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test were treated statistically to compare the ability of the experimental group to place the ball in the tennis court with the ability of the control group to place the ball in the tennis court. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio for the backhand drive of The Broer-Miller Forehand and Backhand Drive Test are shown in

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[13] Ibid.

Table IV, page 60. The mean score of the experimental group was 15.222, and the mean score of the control group was 19.778. The standard error of the mean score of the experimental group was 2.566, and the standard error of the mean score of the control group was 2.568. The mean score of the experimental group and the mean score of the control group were revealed to be reliable, with the mean score of the experimental group shown to be only slightly more accurate than the mean score of the control group. The difference between the means was 4.556, and the standard error of the mean difference was 3.630. The difference between the means and the standard error of the mean difference was judged to be insignificant on the basis of the critical ratio of 1.255. The null hypothesis could not be rejected at the ten per cent level of confidence, and a critical ratio of 2.008 was needed to reject the null hypothesis at the five per cent level of confidence.[14] The experimental group and the control group were regarded to be suitably alike in ability to place the ball in the tennis court when using the backhand drive.

The Teaching Unit

The experimental group, as stated previously, was impartially identified by the toss of a coin. The experimental

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[14] Ibid.

TABLE IV

BROER-MILLER BACKHAND DRIVE TEST RESULTS FOR EQUATING EXPERIMENTAL AND CONTROL GROUPS, SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ M	M diff	σ diff	cr
Experimental N = 27	15.222	2.566	4.556	3.630	1.255*
Control N = 27	19.778	2.568			

* Not significant at the .1 level of confidence.

factor, a device designed to restrict elbow-bend, was applied to the experimental group during twenty-four hour-long periods of instruction in the tennis forehand and backhand drives. The experimental group met from two o'clock to three o'clock on Monday and Wednesday afternoons, and the control group met from two o'clock to three o'clock on Tuesday and Thursday afternoons during the semester.

Six hard-surfaced tennis courts served as the teaching stations for the tennis classes involved in the present study. The classes met in the gymnasium during inclement weather. An official tennis net was used in the gymnasium during the class meetings held inside. The experimental group met in the gymnasium for ten instructional periods. The control group met in the gymnasium for twelve instructional periods.

A progress chart, as illustrated in the Appendix, was prepared for each class. The progress of each subject in the classes was recorded on the chart. The progress chart listed three specific forehand drive practice drills to be executed by the subjects. The forehand drive practice drills, in the order of presentation to the classes, included: (1) stroking a ball dropped by the subject; (2) stroking a ball tossed from the net toward the baseline by the subject's partner; and (3) the rally with the partner. The specific backhand drive drills shown on the progress chart, in the order of presentation to the classes, included: (1) stroking a ball dropped by the subject; (2) stroking a ball tossed from the net toward the baseline by the subject's partner; and (3) the rally with the partner. The forehand drive drills were presented before the backhand drive drills on the progress chart, since the subjects first received forehand drive instructions, then received backhand drive instructions. The date a skill was satisfactorily executed was entered on the chart beside the name of the successful subject.

Members of the experimental class met on the tennis courts on Monday, October 2, 1961, and were introduced to the external device designed to restrict elbow-bend. The subjects worked in pairs, and any two subjects who could be fitted with a device of the same size became partners. The partners unable to wear a device of the same size were fitted individually. The names of the subjects were placed on the devices to identify the device worn by each subject, and to conserve time at the beginning of each class period. The subjects were given a brief review in the fundamentals of the forehand drive. The subjects, during the review in the fundamentals of the forehand drive, were in a semi-circle formation. The subjects practiced the forehand stroke without the use of tennis balls. The verbal method of teaching and the demonstration method of teaching were utilized by the instructor during the review of the fundamentals and throughout the teaching unit. Each subject had approximately fifteen minutes to practice the forehand drive while wearing a device, following the group review of the forehand drive fundamentals. A subject practiced the forehand drive by dropping the ball, then stroking the ball after one bounce. The partner of the subject then wore the device and practiced the forehand drive during the last fifteen minutes of the class meeting. The partners of the performing subjects retrieved the balls already hit. Emphasis was placed on the backswing, the shift of the weight, and the follow-through. Individual instruction was given as the subjects practiced the forehand drive. The subjects had been given instructions in the forehand drive and the backhand drive fundamentals, including the grip, the stance, the backswing, the shift of the weight, and the follow-through, during the class meeting prior to the administration of the tests.

Each member of the experimental group was given at least thrity minutes of instruction and practice in the forehand and backhand drives during the remainder of the teaching unit. The subjects were introduced to additional types of forehand drive practice, and to the backhand drive fundamentals and drills, as the skills listed on the progress chart were performed satisfactorily.

The control group met on the tennis courts on Tuesday, October 3, 1961, and each member of the class chose a partner.

The class was given a brief review in the fundamentals of the forehand drive. The subjects, during the review in the fundamentals of the forehand drive, were in a semi-circle formation, and the forehand stroke was practiced without the use of the tennis balls. The verbal method of teaching and the demonstration method of teaching were utilized by the instructor during the review of the fundamentals and throughout the teaching unit. Each subject had approximately twenty minutes to practice the forehand following the group review of the forehand drive fundamentals. A subject practiced the forehand drive by dropping the ball, then stroking the ball after one bounce. The partner of the subject then practiced the forehand drive during the last twenty minutes of the class meeting. The partners of the performing subjects retrieved the balls already hit. Emphasis was placed on the backswing, the shift of the weight, and the follow-through. Individual instruction was given as the subjects practiced the forehand drive. The subjects had been given instructions in the forehand drive and the backhand drive fundamentals, including the grip, the stance, the backswing, the shift of the weight, and the follow-through, during the class meeting prior to the administration of the tests.

Each member of the control group was given at least thirty minutes of instruction and practice in the forehand and backhand drives during the remainder of the teaching unit.

The subjects were introduced to additional types of forehand drive practice, and to the backhand drive fundamentals and drills, as the skills listed on the progress chart were performed satisfactorily.

A detailed outline of the essential elements of the forehand drive and the backhand drive used in the teaching unit for the experimental group and the control group, is included in the Appendix.

The twenty-fifth, and final, period of instruction for the experimental group was conducted on Friday, January 5, 1962, at two o'clock. The twenty-fifth, and final, period of instruction for the control group was conducted on Friday, January 5, 1962, at three o'clock. The classes met for extra session on Friday in order to complete the twenty-five instructional periods required for the present study.

Three members of the experimental group could not perform satisfactorily the second phase of the backhand drive, hitting the ball tossed from the net by the partner, at the conclusion of the teaching unit. One member of the experimental class could not satisfactorily perform the second phase of the forehand drive, hitting the ball tossed from the net by the partner, at the conclusion of the teaching unit. Two members of the experimental class had satisfactorily mastered the forehand drive rally, and two of the experimental subjects had successfully executed the backhand rally at the conclusion of the teaching unit.

Two members of the control group had failed to perform satisfactorily the first phase of the backhand drive skills and three members of the control group failed to perform satisfactorily the second phase of the backhand drive skills as shown on the progress chart. Two control subjects were not successful in attempting to hit the ball tossed from the net by the partner, when using the forehand drive. One member of the control group was unable to execute the first phase of the forehand drive, dropping the ball and hitting the ball following one bounce. Eleven members of the control group had successfully executed the forehand drive rally at the conclusion of the teaching unit, but none of the control subjects had satisfactorily mastered the backhand drive rally.

The achievement of the experimental group and the control group subjects, as revealed by the progress charts, is shown in Table V, page 67.

The Final Tests and the Judges' Ratings for Comparing the Groups

The first of the final tests to be given for the purpose of comparing the groups, in terms of achievement and form, was The Broer-Miller Forehand and Backhand Drive Test. The test was administered indoors because of inclement weather. The Sul Ross State College gymnasium was not adequate

TABLE V

ACHIEVEMENT OF EXPERIMENTAL AND CONTROL GROUP SUBJECTS, AS RECORDED ON PROGRESS CHARTS

Group	Forehand Drive: Toss to Self	Forehand Drive: Toss from Partner	Forehand Drive: Rally	Backhand Drive: Toss to Self	Backhand Drive: Toss from Partner	Backhand Drive: Rally
Control	26	25	11	25	24	0
Experimental	27	26	2	27	24	2

in length to accomodate The Broer-Miller Forehand and Backhand Drive Test; therefore, arrangements were made to administer the test in the gymnasium of the Alpine High School, Alpine, Texas.

The special court markings of masking tape, the official tennis net, and the rope four feet above the net were placed in the high school gymnasium during the noon hour on Monday, January 8, 1962, and all members of the experimental group were notified concerning the test arrangements. The experimental group began The Broer-Miller Forehand and Backhand Drive Test at one o'clock. The final administration of The Broer-Miller Forehand and Backhand Drive Test was conducted in the same manner as was the initial test given prior to the teaching unit. Exceptions were: (1) the first test was given outside and on two tennis courts, whereas the final test was administered inside and on one tennis court; (2) the subjects were tested in alphabetical order during the initial test, and the subjects were tested in the order of arrival at the high school gymnasium during the second administration of the test; and (3) the subjects executed the forehand drive test on one court, then proceeded to a second court for the backhand drive test during the first test administration; however, the subjects were given the forehand drive test and, immediately afterward, the backhand drive test was given on the same court, with no noticeable lapse of time occurring between the forehand drive test and the backhand drive test during the final test administration. The experimental group completed the final administration of The Broer-Miller Forehand and Backhand Drive Test at approximately four o'clock in the afternoon.

The final administration of The Broer-Miller Forehand and Backhand Drive Test for the control group was conducted on Tuesday, January 9, 1962, in the Alpine High School gymnasium because of inclement weather. Members of the control group were notified of the arrangements concerning the test, and the testing began at one o'clock.

The procedures for administering The Broer-Miller Forehand and Backhand Drive Test to the experimental group and the control group were identical. The final administration of The Broer-Miller Forehand and Backhand Drive Test for the control group was completed at approximately four o'clock.

The second of the final tests to be given, for the purpose of comparing the groups in terms of achievement and form, was The Dyer Backboard Test of Tennis Ability. The test was administered in the Sul Ross State College gymnasium. Members of the experimental group and members of the control group were informed concerning the test arrangements during the last previous class meetings at the high school gymnasium. The two end walls of the college gymnasium were used for the administration of The Dyer Backboard Test of Tennis Ability.

The procedures followed during the administration of the test for each group were identical with the procedures followed during the initial test administration prior to the teaching unit. The experimental group and the control group completed The Dyer Backboard Test of Tennis Ability during the respective one-hour class periods.

The Dyer Backboard Test of Tennis Ability was administered to the experimental group on Wednesday, January 10, 1962. The subjects were given instructions at the completion of The Dyer Backboard Test of Tennis Ability concerning the subjective ratings to be conducted on Friday, January 12, 1962.

The Dyer Backboard Test of Tennis Ability was administered to the control group on Thursday, January 11, 1962. The subjects were given instructions at the completion of The Dyer Backboard Test of Tennis Ability concerning the subjective ratings to be conducted on Friday, January 12, 1962.

The subjective ratings committee was comprised of three tennis authorities. Each of the three judges was asked, prior to the beginning of the study, to serve on the committee. Each committee member was supplied with a summary of the elements of the forehand drive and the elements of the backhand drive included in the teaching unit. An exact duplicate of the summary furnished the judges is shown in the Appendix.

The chart to be used by the judges in rating the form of the subjects was completed and sent to the judges at the same time as the summary of the elements of good form in the forehand and backhand drives. The chart used by the judges, as illustrated in Figure 3, page 72, allowed the subjects to be rated on the backswing, stroke, and follow-through during the execution of the forehand and backhand drives. Ten points were scored when a subject met all the specifications for good form as described by the summary of the elements of the forehand and backhand drives. Eight or nine points were scored by a subject giving a general impression of good form, with only minor variations from the described specifications for good form. Six or seven points were awarded a subject evidencing a lack of competence in some of the elements of good form, but with fairly smooth stroke execution. Four or five points were scored by a subject evidencing some mastery of the elements of good form, but showing a lack of smoothness in performance and revealing errors. Two or three points were awarded a subject failing to meet most of the specifications of good form, and one point was given a subject failing to meet any of the specifications of good form, but executing the phases of the strokes. The chart included a key to be used by the judges to explain the weaknesses of subjects rating below the maximum of ten points. The key was as follows: the letter B referred to body position; the letter A referred to the arm and the wrist; the letter R referred to the racket

10 points	8-9 points	6-7 points	4-5 points	2-3 points	1 point
Player meets listed specifications for good form.	Player gives general impression of good form with only minor variations from described specifications for good form.	Player evidences lack of competence in some elements; however, execution is fairly smooth.	Player evidences some mastery of elements of good form but performance lacks smoothness and contains errors.	Player fails to meet practically all specifications for good form.	Player fails to meet specifications for good form but does execute phases of strokes.

Note to judges: If player rates below maximum, use key given below to explain player weakness. Place proper letter(s) immediately past numerical evaluations. B - body position; A - arm and wrist; R - racket position; G - grip; E - elbow bend.

	FOREHAND DRIVE				BACKHAND DRIVE			
Name of Player	Back-swing	Stroke	Follow-Through	Total Points	Back-swing	Stroke	Follow-Through	Total Points

FIGURE 3

JUDGES RATINGS WITH DESCRIPTIVE CRITERIA FOR STROKE EVALUATION position; the letter G referred to the grip; and the letter E referred to elbow-bend. The judges were asked to place the proper letter(s) immediately past the numerical evaluations on the charts. The highest possible score for the forehand drive was thirty points, and the highest possible score for the backhand drive was thirty points.

The subjects were rated by the judges on Friday, January 12, 1962, and the ratings were used in comparing the control group and the experimental group in terms of form during the execution of the forehand and backhand drives. The ratings were conducted in the Sul Ross State College gymnasium. An official tennis net was needed in the gymnasium, and an adequate number of tennis rackets and tennis balls were appropriately placed in the gymnasium. The names of the members of the experimental group and the control group were placed in alphabetical order on the judges' ratings charts in order that the judges remain unaware of the group identity of each subject. The three judges arrived at the gymnasium at twelve-thirty o'clock and each judge was furnished a clipboard containing the charts with the alphabetized names of the subjects. The subjects began arriving at one o'clock. One judge was seated on the west side of the gymnasium near the south end of the permanent bleachers. The two other judges were seated on the east side of the gymnasium near the south end of the permanent bleachers. The two judges seated on the east side of the gymnasium were approximately twenty feet apart. The subjects were rated in the order of arrival at the gymnasium. The subject was given a racket and asked to stand facing the net and near the south end of the gymnasium, midway between the bleachers. The subject was asked to execute the forehand drive, to be followed by the backhand drive. The writer stood near the net midway between the bleachers. The writer was on the north side of the net and tossed the tennis balls toward the subject. The box of tennis balls was situated near the writer. Each subject was asked to hit seven balls using the forehand drive, and seven balls using the backhand drive. The judges were given the name of the subject preparing to perform. The writer checked with each judge before making the initial toss to the forehand side of the subject and before making the initial toss to the backhand side of the subject. Two women physical education majors retrieved the balls already hit and returned the balls to the box near the writer. The writer tossed seven balls to the forehand side of each subject, allowing a momentary lapse of time between tosses. Additional balls were tossed to the forehand side of a subject at the request of any of the judges. The judges signalled the writer as each subject had been rated on the forehand drive. The subject was then asked to execute the backhand drive. The writer tossed seven balls to the backhand side of the subject, allowing a momentary lapse of time between tosses. Additional balls were tossed to the backhand side of a subject at the request of any of the judges. The judges signalled the writer as each subject had been rated on the backhand drive. The momentary lapse of time between tosses permitted the subject to return to the readiness position, facing the net, before each stroke. The subjective ratings of the fifty-four subjects were completed at four o'clock.

A high level of agreement between the judges was necessary as an indication that the judges were applying essentially the same standard to the subjects being ranked, regardless of other considerations. No objective measure was available for the evaluation of the form displayed by the subjects during the forehand and backhand drives. The opinions and value judgments of the three judges were the only means of determining the rankings of the subjects. Any great disagreement between the judges would occur in the event the judges applied different standards, or different interpretations to the same standards, to the subjects being ranked. The degree of agreement between the three judges in the rankings of the subjects was determined by the statistical device, the coefficient of concordance (W).

Statistical Treatment of the Data for Comparing the Groups

The degree of agreement between the judges, as stated previously, was determined by computing the coefficient of concordance (W). The formula for the coefficient of concordance, as given by Edwards, was:[15]

$$W = \frac{\text{sum of squares between columns}}{\text{total sum of squares}}$$

when the

$$\text{total sum of squares} = \frac{m(n^3-n)}{12}$$

and the

$$\text{sum of squares between columns} = \frac{\text{sum of rows squared}}{3} - \frac{mn(n+1)^2}{4}$$

The significance of the coefficient of concordance was determined to test the null hypothesis: the observed agreement between the judges was a matter of chance. The significance of the coefficient of concordance was calculated using the statistical device, the F test. The formula for the F test is as follows:[16]

$$F = \frac{(m-1)\ W}{1-W}$$

The degrees of freedom for the numerator (df_1) of the

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[15] *Ibid.*, p. 405.

[16] *Ibid.*, p. 410.

F ratio, and the degrees of freedom for the denominator (df_2) of the F ratio were discovered by applying the following formulas:[17]

$$df_1 = (n-1) - \frac{2}{M}$$

$$df_2 = (m-1)\left[(n-1) - \frac{2}{m}\right]$$

The experimental group and the control group were compared on the basis of achievement and on the basis of correct stroke execution or form. The average achievement within each group was measured by comparing the scores on the first administration of The Dyer Backboard Test of Tennis Ability with the scores on the second administration of the test. The average achievement in each group was also measured by comparing the scores on the first administration of The Broer-Miller Forehand and Backhand Drive Test with scores on the second administration of the test. The comparisons involved the use of the formulas for the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio, as previously presented in the present chapter. The average achievement in the experimental group was compared with the average achievement in the control group by computing the cirtical ratio

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[17] *Ibid*.

from the achievement data within each group for The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test. The comparison of the experimental group and the control group on the basis of correct stroke execution or form was determined from the results of the subjective ratings. The comparison of the two groups on the basis of correct stroke execution or form involved the use of the formulas for the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio, as previously presented in the present chapter.

A detailed description and interpretation of the statistical results of the comparison of the experimental group and the control group are presented in Chapter IV.

CHAPTER IV

INTERPRETATION OF THE STATISTICAL RESULTS OF THE STUDY

A specific purpose of the present study was to compare the experimental group and the control group in terms of achievement and performance following the completion of the teaching unit involving instruction in the tennis forehand and backhand drives. This chapter presents the comparison of the two groups as evidenced through the statistical treatment of data obtained from (1) The Dyer Backboard Test of Tennis Ability, (2) The Broer-Miller Forehand and Backhand Drive Test, and (3) the Judges' Subjective Ratings.

The Dyer Backboard Test of Tennis Ability

No significant improvement was evidenced by the experimental group in the performance of The Dyer Backboard Test of Tennis Ability. The group's scores on the test administered in September and the group's scores on the test administered in January were treated statistically in order to determine the achievement of the group in performing the specific skills involved in The Dyer Backboard Test of Tennis Ability. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio, calculated through the use of the formulas shown in Chapter III, are shown in Table VI, page 81. The mean score for the initial test was 44.074, and the standard error of the mean score was 2.489. The chances are 68.26 in 100, therefore, that the true mean lies between 44.074 ± 2.489. The mean score for the final test was 46.851, and the standard error of the mean was 3.50. The chances are 68.26 in 100 that the true mean lies within the limits of 46.851 ± 3.50. The difference in the means was 2.777, and the standard error of the mean difference was 4.292. The reliability of the mean difference was calculated in the same manner as was the reliability of the mean. The chances are 68.26 in 100 that the true mean difference rests between 2.77 ± 4.292. The critical ratio was calculated to determine if the mean difference were sufficiently significant to reject the null hypothesis. The critical ratio was .647, and the null hypothesis, i.e., there was no significant difference between the means, could not be rejected. A critical ratio of 2.056 was required to reject the null hypothesis at the five per cent level of confidence.

The control group did not show any significant improvement in the performance of The Dyer Backboard Test of Tennis Ability. The group's scores on the test administered in September and the group's scores on the test administered in January were treated statistically in order to determine the achievement of the group in performing the

TABLE VI

RESULTS OF DYER BACKBOARD TEST OF TENNIS ABILITY FOR MEASURING ACHIEVEMENT OF EXPERIMENTAL GROUP SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental[1] N = 27	44.074	2.489	2.777	4.292	.647*
Experimental[2] N = 27	46.851	3.5			

*Not significant at the .1 level of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

specific skills involved in The Dyer Backboard Test of Tennis Ability. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio are shown in Table VII, page 83. The mean score for the first test was 46.444, and the standard error of the mean score was 3.167. The chances are 68.26 in 100 that the true mean lies between 46.444 $\pm$ 3.167. The mean score for the final test was 50.0, and the standard error of the mean was 3.61. The chances are 68.26 in 100 that the true mean rests between 50.0 $\pm$ 3.61. The difference between the two means was 3.556, and the standard error of the mean difference was 4.802. The chances are 68.26 in 100 that the true mean difference lies between 3.556 $\pm$ 4.802. The critical ratio was calculated to determine if the mean difference were sufficiently significant to reject the null hypothesis. The critical ratio was .704 and indicated no significant difference between the two means. A critical ratio of 2.056 was required to reject the null hypothesis at the five per cent level of confidence.

The final scores of the experimental group were compared with the final scores of the control group in order to compare the achievement of the groups in performing the specific skills involved in The Dyer Backboard Test of Tennis Ability. The means, the standard error of the means, the mean difference, the standard error of the mean difference,

TABLE VII

RESULTS OF DYER BACKBOARD TEST OF TENNIS ABILITY FOR MEASURING ACHIEVEMENT OF CONTROL GROUP SHOWING MEANS, STANDARD ERROR OF THE MEANS, MEAN DIFFERENCE, STANDARD ERROR OF THE MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Control[1] N = 27	46.44	3.167	3.556	4.802	.704*
Control[2] N = 27	50.	3.61			

*Not significant at the .1 level of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

and the critical ratio are shown in Table VIII, page 85. The mean score for the experimental group was 46.851, and the standard error of the mean score was 3.50. The chances are 68.26 in 100 that the true mean lies between 46.851 ± 3.50. The mean score for the control group was 50.0, and the standard error of the mean was 3.61. The chances are 68.26 in 100 that the true mean rests between 50.0 ± 3.61. The difference between the two means was 3.149, and the standard error of the mean difference was 2.666. The chances are 68.26 in 100 that the true mean difference lies between 3.149 ± 2.666. The critical ratio was 1.181 and indicated no significant difference between the means of the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

The Broer-Miller Forehand and Backhand Drive Test

The Forehand Drive. The experimental group revealed improvement of some significance in the performance of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The group's scores on the test administered in September were compared with the group's scores on the test administered in January by calculating the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio as shown in Table IX, page 86. The mean score for

TABLE VIII

RESULTS OF DYER BACKBOARD TEST OF TENNIS ABILITY FOR COMPARING EXPERIMENTAL AND CONTROL GROUPS SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental N = 27	46.851	3.5	3.149	2.666	1.181*
Control N = 27	50.	3.61			

* Not significant at the .1 level of confidence.

TABLE IX

RESULTS OF BROER-MILLER FOREHAND DRIVE TEST FOR MEASURING ACHIEVEMENT OF EXPERIMENTAL GROUP SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental [1] N = 27	31.851	2.838	6.945	3.609	1.924*
Experimental [2] N = 27	38.796	2.204			

* Significant between .1 and .05 levels of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

the first test was 31.851, and the standard error of the mean was 2.838. The chances are 68.26 in 100 that the true mean rests between 31.851 ± 2.838. The mean score for the final test was 38.796, and the standard error of the mean was 2.204. The chances are 68.26 in 100 that the true mean lies between 38.796 ± 2.204. The mean difference was 6.945, and the standard error of the mean difference was 3.609. The chances are 68.26 in 100 that the true mean difference lies between 6.945 ± 3.609. The critical ratio was found to be 1.924, which indicated the null hypothesis could be rejected at a point between the five and ten per cent levels of confidence.

The control group revealed major improvement in the performance of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The group's scores from the first test were compared with the group's scores from the second test by computing the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio as shown in Table X, page 88. The mean score for the first test was 26.649, and the standard error of the mean was 1.811. The chances are 68.26 in 100 that the true mean lies between 26.649 ± 1.811. The mean score for the final test was 37.0, and the standard error of the mean was 2.314. The chances are 68.26 in 100 that the true mean lies between 37.0 ± 2.314. The mean difference was 10.351, and the standard error of the mean

TABLE X

RESULTS OF BROER-MILLER FOREHAND DRIVE TEST FOR MEASURING ACHIEVEMENT OF CONTROL GROUP SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Control[1] N = 27	26.649	1.811	10.351	3.672	2.818*
Control[2] N = 27	37.0	2.314			

* Significant at the .01 level of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

difference was 3.672. The chances are 68.26 in 100 that the true mean difference rests between 10.351 ± 3.672. The critical ratio was 2.818, which indicated the improvement of the group, as evidenced by the mean difference, to be significant in that the null hypothesis could be rejected at the one per cent level of confidence.

The final scores of the experimental group were compared with the final scores of the control group in order to compare the achievement of the two groups in performing the specific skills involved in the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio are shown in Table XI, page 90. The mean score for the experimental group was 38.796, and the standard error of the mean was 2.204. The chances are 68.26 in 100 that the true mean lies between 38.796 ± 2.204. The mean score for the control group was 37.0, and the standard error of the mean was 2.314. The chances are 68.26 in 100 that the true mean rests between 37.0 ± 2.314. The difference between the two means was 1.796, and the standard error of the mean difference was 3.195. The chances are 68.26 in 100 that the true mean difference lies between 1.796 ± 3.195. The critical ratio was .562, which indicated no significant difference between the means of the two groups. A critical ratio of

TABLE XI

RESULTS OF BROER-MILLER FOREHAND DRIVE TEST FOR COMPARING EXPERIMENTAL AND CONTROL GROUPS SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental N = 27	38.796	2.204	1.796	3.195	.562*
Control N = 27	37.0	2.314			

* Not significant at the .1 level of confidence.

2.008 was necessary to reject the null hypothesis at the five per cent level of confidence.

The Backhand Drive. The experimental group showed remarkable improvement in the performance of the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The group's scores from the first test were compared with the group's scores from the second test by calculating the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio as shown in Table XII, page 92. The mean score for the first test was 15.222, and the standard error of the mean was 2.566. The chances are 68.26 in 100 that the true mean lies between 15.222 ± 2.566. The mean score for the final test was 37.220, and the standard error of the mean was .763. The chances are 68.26 in 100 that the true mean lies between 37.220 ± .763. The mean difference was 21.998, and the standard error of the mean difference was 2.676. The chances are 68.26 in 100 that the true mean difference rests between 21.998 ± 2.676. The critical ratio was 8.220 which indicated the improvement of the group, as evidenced by the mean difference, to be significant in that the null hypothesis could be rejected at the one per cent level of confidence.

The control group showed significant improvement in the performance of the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The group's scores

TABLE XII

RESULTS OF BROER-MILLER BACKHAND DRIVE TEST FOR MEASURING ACHIEVEMENT OF EXPERIMENTAL GROUP SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ M	M diff	σM diff	cr
Experimental [1] N = 27	15.222	2.566	21.998	2.676	8.220*
Experimental 2 N = 27	37.220	.763			

* Significant at .01 level of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

from the first test were compared with the group's scores from the second test by calculating the means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio as shown in Table XIII, page 94. The mean score for the first test was 19.778, and the standard error of the mean was 2.568. The chances are 68.26 in 100 that the true mean lies between 19.778 ± 2.568. The mean score for the second test was 32.444, and the standard error of the mean was .864. The chances are 68.26 in 100 that the true mean lies between 32.444 ± .864. The mean difference was 12.666, and the standard error of the mean difference was 2.709. The chances are 68.26 in 100 that the true mean difference lies between 12.666 ± 2.709. The critical ratio was 4.675 which indicated the improvement of the group, as evidenced by the mean difference, to be significant in that the null hypothesis could be rejected at the one per cent level of confidence.

The final scores of the experimental group were compared with the final scores of the control group in order to compare the achievement of the two groups in performing the specific skills involved in the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio are shown in Table XIV, page 95. The mean score for the

TABLE XIII

RESULTS OF BROER-MILLER BACKHAND DRIVE TEST FOR MEASURING ACHIEVEMENT OF CONTROL GROUP SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	σ_M diff	cr
Control[1] N = 27	19.778	2.568	12.666	2.709	4.675*
Control[2] N = 27	32.444	.864			

*Significant at .01 level of confidence.

[1]Data obtained in September, 1961.

[2]Data obtained in January, 1962.

TABLE XIV

RESULTS OF BROER-MILLER BACKHAND DRIVE TEST FOR COMPARING EXPERIMENTAL AND CONTROL GROUPS SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental N = 27	37.220	.763	4.776	1.152	4.145*
Control N = 27	32.444	.864			

* Significant at .01 level of confidence.

experimental group was 37.220, and the standard error of the mean was .763. The chances are 68.26 in 100 that the true mean rests between 37.220 ± .763. The mean score for the control group was 32.444, and the standard error of the mean was .864. The chances are 68.26 in 100 that the true mean lies between 32.444 ± .864. The mean difference was 4.776, and the standard error of the mean difference was 1.152. The chances are 68.26 in 100 that the true mean difference lies between 4.776 ± 1.152. The critical ratio was 4.145 which indicated the difference between the experimental mean and the control mean to be significant, in that the null hypothesis could be rejected at the one per cent level of confidence.

The Judges' Subjective Ratings

The Forehand Drive. The judges' subjective rating scores of the experimental group and the judges' subjective rating scores of the control group were treated statistically in order to compare the two groups in terms of correct stroke execution or form in performing the forehand drive. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio are shown in Table XV, page 97. The mean score for the experimental group was 58.796, and the standard error of the mean was 1.703. The chances are 68.26 in 100 that the true mean lies between 58.796 ± 1.703. The

TABLE XV

RESULTS OF JUDGES' RATINGS OF FOREHAND DRIVE FOR COMPARING FORM OF EXPERIMENTAL AND CONTROL GROUPS SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ_M	M diff	$\sigma_{M\ diff}$	cr
Experimental N = 27	58.796	1.703	3.241	2.523	1.284*
Control N = 27	55.555	1.862			

* Not significant at the .1 level of confidence.

mean score for the control group was 55.555, and the standard error of the mean was 1.862. The chances are 68.26 in 100 that the true mean lies between 55.555 $\pm$ 1.862. The mean difference was 3.241, and the standard error of the mean difference was 2.523. The chances are 68.26 in 100 that the true mean difference lies between 3.241 $\pm$ 2.523. The critical ratio was 1.284 which indicated no significant difference between the means of the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

The Backhand Drive. The judges' subjective rating scores of the experimental group and the judges' subjective rating scores of the control group were treated statistically in order to compare the two groups in terms of correct stroke execution or form in performing the backhand drive. The means, the standard error of the means, the mean difference, the standard error of the mean difference, and the critical ratio are presented in Table XVI, page 99. The mean score for the experimental group was 57.444, and the standard error of the mean was 1.621. The chances are 68.26 in 100 that the true mean lies between 57.444 $\pm$ 1.621. The mean score for the control group was 57.111, and the standard error of the mean was 1.760. The chances are 68.26 in 100 that the true mean rests between 57.111 $\pm$ 1.760. The mean difference was .333, and the standard error of the mean difference was 2.372.

TABLE XVI

RESULTS OF JUDGES RATINGS OF BACKHAND DRIVE FOR COMPARING FORM OF EXPERIMENTAL AND CONTROL GROUPS SHOWING MEANS, STANDARD ERROR OF MEANS, MEAN DIFFERENCE, STANDARD ERROR OF MEAN DIFFERENCE, AND CRITICAL RATIO

	M	σ M	M diff	σM diff	cr
Experimental N = 27	57.444	1.621	.333	2.372	.140*
Control N = 27	57.111	1.760			

* Not significant at the .1 level of confidence.

The chances are 68.26 in 100 that the true mean difference lies between .333 $\pm$ 2.372. The critical ratio was .140 which indicated no significant difference between the means of the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

The Test for Agreement Between the Judges. The need for a high level of agreement between the judges comprising the subjective ratings committee was discussed in the previous chapter. The level of agreement between the judges, as stated previously, was determined by computing the coefficient of concordance (W). The significance of the coefficient of concordance was calculated by utilizing the F test. The coefficient of concordance (W), the F ratio, the degrees of freedom for the denominator, and the degrees of freedom for the numerator are shown in Table XVII, page 101. The coefficient of concordance (W) was .401. Perfect agreement between the judges would have revealed W to be 1.0. The null hypothesis involved was that the observed agreement between the judges was a matter of chance. The value of W would be zero were the null hypothesis proven to be true. The F ratio was 1.507, the degrees of freedom for the denominator were 104.668, and the degrees of freedom for the numerator were 52.334. The F ratio of 1.507 indicated the coefficient of concordance, .401, to be significant to the extent that the null hypothesis

TABLE XVII

RESULTS OF W TEST FOR AGREEMENT BETWEEN JUDGES SHOWING DEGREES OF FREEDOM AND F RATIO FOR SIGNIFICANCE OF W

	df denominator	df numerator	F
W = .401*	104.668	52.334	1.507

*Significant to reject the null hypothesis at the .05 level of confidence.

was rejected at the five per cent level of confidence.

The summary, conclusions, and recommendations of the study are presented in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

The purpose of the present study was to determine the value of an external device which would eliminate the tendency of beginning tennis players to bend the elbow when learning the forehand and backhand drives. The study was conducted at Sul Ross State College, Alpine, Texas, during the fall semester of the academic year, 1961-62, and involved the two women's physical education tennis classes.

The first step in the study was that of selecting a suitable device for restricting elbow-bend. The device was designed and constructed by an orthopedic brace specialist. Efficiency of purpose, safety, and comfort were considered the essential criteria in the selection of the device. The device was designed and constructed as a cradle-type, posterior elbow brace to hold the elbow in a position of one hundred eighty degrees extension.

The second step in the study involved the selection of the control group and the experimental group. Enrollees in two women's physical education classes served as subjects for the study. The only requisite for enrolling in either of the classes was that members had received no previous tennis instruction. Group I met class on Monday and Wednesday afternoons from one to two o'clock, and Group II met class on Tuesday and Thursday afternoons from one to two o'clock. The experimental group was impartially identified by the toss of a coin, and Group I served as the experimental group, while Group II served as the control group. The experimental group was comprised of twenty-seven women physical education students, and the control group was comprised of twenty-seven women physical education students. The equating of the experimental group and the control group involved the administration of The Scott Motor Ability Test, The Dyer Backboard Test of Tennis Ability, and The Broer-Miller Forehand and Backhand Drive Test.

The third step of the investigation was that of applying the device designed to restrict elbow-bend to the experimental group. The device was applied to the experimental group during twenty-four hour-long periods of instruction in the tennis forehand and backhand drives. The verbal method of teaching and the demonstration method of teaching were utilized by the instructor throughout the teaching unit in the experimental class and in the control class.

The fourth and final step of the study was to compare the experimental group and the control group in terms of achievement and performance following the completion of the teaching unit. The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test were repeated as a basis for comparing the achievement of the groups. The judges' subjective ratings served to compare the groups in terms of correct stroke execution or form.

Summary of the Statistical Results

The Comparison of the Groups in Terms of Achievement. On the basis of the scores obtained on The Dyer Backboard Test of Tennis Ability and The Broer-Miller Forehand and Backhand Drive Test, the comparison of the groups is summarized as follows:

1. The experimental group did not reveal any significant improvement in the performance of The Dyer Backboard Test of Tennis Ability. The statistical treatment of the data yielded a critical ratio of .647, and the null hypothesis could not be rejected. A critical ratio of 2.056 was required to reject the null hypothesis at the five per cent level of confidence.

2. The control group did not show any significant improvement in the performance of The Dyer Backboard Test of Tennis Ability. The statistical treatment of the data revealed a critical ratio of .704, and a critical ratio of 2.056 was required to reject the null hypothesis at the five per cent level of confidence.

3. The comparison of the final scores from The Dyer Backboard Test of Tennis Ability revealed a mean difference

of 3.149 in favor of the control group. The statistical treatment of the data yielded a critical ratio of 1.181 and indicated no significant difference between the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

4. The experimental group revealed improvement of minor significance in the performance of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the data yielded a critical ratio of 1.924, which indicated the null hypothesis could be rejected at a point between the five and ten per cent levels of confidence.

5. The control group revealed significant improvement in the performance of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the data yielded a critical ratio of 2.818, which indicated the null hypothesis could be rejected at the one per cent level of confidence.

6. The comparison of the final scores from the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test revealed a mean difference of 1.796 in favor of the experimental group. The statistical treatment of the data yielded a critical ratio of .562, which indicated no significant difference between the two groups. A critical ratio of 2.008 was necessary to reject the null hypothesis

at the five per cent level of confidence.

7. The experimental group revealed significant improvement in the performance of the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the data yielded a critical ratio of 8.220, which indicated the null hypothesis could be rejected at the one per cent level of confidence.

8. The control group showed significant improvement in the performance of the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the data revealed a critical ratio of 4.675, which indicated the null hypothesis could be rejected at the one per cent level of confidence.

9. The comparison of the final scores from the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test revealed a mean difference of 4.776 in favor of the experimental group. The statistical treatment of the data yielded a critical ratio of 4.145, which indicated a significant difference between the two groups in that the null hypothesis could be rejected at the one per cent level of confidence.

10. The comparison of the scores from the judges' subjective ratings of form during the execution of the forehand drive revealed a mean difference of 3.241 in favor of the experimental group. The statistical treatment of the

data yielded a critical ratio of 1.284, which indicated no significant difference between the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

11. The comparison of the scores from the judges' subjective ratings of form during the execution of the back-hand drive revealed a mean difference of .333 in favor of the experimental group. The statistical treatment of the data yielded a critical ratio of .140, which indicated no significant difference between the two groups. A critical ratio of 2.008 was required to reject the null hypothesis at the five per cent level of confidence.

12. The coefficient of concordance (W) was the statistical device employed to test for agreement between the judges comprising the subjective ratings committee. The coefficient of concordance (W) was .401. The F ratio was calculated to determine the significance of W. The F ratio of 1.507 indicated the coefficient of concordance, .401, to be significant to the extent that the null hypothesis was rejected at the five per cent level of confidence.

Conclusions

As stated in Chapter I, four basic assumptions were made by the investigator in initiating the present study: (1) there is a need for research in teaching techniques for physical education; (2) an understanding of how learning occurs is a requisite for research in teaching techniques; (3) kinesthetic perception is an essential experience in learning motor skills; and (4) the tendency to bend the elbow is a common fault of beginning tennis players in learning the forehand and backhand drives. Following thorough consideration of the basic assumptions, a general hypothesis was posed.

The general hypothesis proposed for the study was that an external device, designed to restrict elbow-bend in tennis forehand and backhand drives would effect kinesthetic understanding and facilitate the acquisition of the skills. The conclusions were based on the general hypothesis as it related to the achievement and performance of the experimental group and the control group during the execution of the specific skills involved in The Dyer Backboard Test of Tennis Ability, The Broer-Miller Forehand and Backhand Drive Test, and the judges' subjective ratings of the form displayed during the execution of the forehand and backhand drives. The conclusions were as follows:

1. The hypothesis could not be accepted as it related to the achievement and performance of the specific skills involved during the execution of The Dyer Backboard Test of Tennis Ability. The statistical treatment of the scores obtained by the experimental group failed to reveal any value

relating to the device designed to restrict elbow-bend. The control group failed to show any significant achievement in the performance of the skills involved in The Dyer Backboard Test of Tennis Ability.

2. The hypothesis could not be accepted as it related to the achievement and performance of the specific skills involved during the execution of the forehand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the scores obtained by the experimental group revealed improvement of minor significance. The improvement could not be attributed to the use of the device designed to restrict elbow-bend, because the control group was shown to have made highly significant improvement, and no significant difference between the two groups was revealed in the final statistical analysis.

3. The hypothesis seemed to be substantiated as it related to the backhand drive phase of The Broer-Miller Forehand and Backhand Drive Test. The statistical treatment of the scores obtained by the experimental group revealed improvement of major significance. The control group was shown to have made significant improvement also. The final statistical analysis revealed a significant difference between the two groups in favor of the experimental group.

4. The hypothesis could not be accepted as it related to correct forehand drive execution as determined by the

judges' subjective ratings. The statistical analysis of the ratings obtained by the experimental group and the ratings obtained by the control group revealed no significant difference between the two groups.

5. The hypothesis could not be accepted as it related to correct backhand execution as determined by the judges' subjective ratings. The statistical analysis of the ratings obtained by the experimental group and the ratings obtained by the control group revealed no significant difference between the two groups.

Recommendations

The present study involved two specific women's physical education classes at a specific institution of higher education, Sul Ross State College, Alpine, Texas. However, the apparent value of a device designed to restrict elbow-bend in teaching the tennis backhand drive, as revealed by The Broer-Miller Forehand and Backhand Drive Test, seemed to warrant the following recommendations:

1. Conduct a more widespread study of the possible value of a device designed to restrict elbow-bend in teaching the backhand drive. Such a study should include physical education classes in public schools and colleges and universities.

2. Conduct similar studies to determine the value of

a movement-restriction device when teaching various other activities: (1) such a device might be applied to the left arm of a right-handed subject, and to the right arm of a left-handed subject when teaching the golf drive; and (2) a similar device might be applied to the knees of a subject to restrict the amount of flexion when teaching the flutter kick in swimming.

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APPENDIX

FORM USED IN RECORDING SCORES FOR THE DYER BACKBOARD TEST OF TENNIS ABILITY

DYER BACKBOARD TEST OF TENNIS ABILITY

Name of Student ________________________________

First Trial

A. No. of balls hitting scoring area on wall ______

B. Violations ______

Second Trial

A. No. of balls hitting scoring area on wall ______

B. Violations ______

Third Trial

A. No. of balls hitting scoring area on wall ______

B. Violations ______

Total: ______

FOREHAND DRIVE AND BACKHAND DRIVE
PROGRESS CHART

Name of Subject	Forehand Drive: Toss to Self	Forehand Drive: Toss from Partner	Forehand Drive: Rally	Backhand Drive: Toss to Self	Backhand Drive: Toss from Partner	Backhand Drive: Rally

ELEMENTS OF FOREHAND DRIVE

I. Backswing

A. Body Position.

1. Left foot in front.
2. Left shoulder toward net.
3. Weight shifted to right foot.
4. Slight knee flexion.

B. Arm and wrist.

1. Arm extended.
2. Arm far enough from body to allow freedom of movement from shoulder.
3. Wrist locked.

C. Racket position.

1. Racket head above wrist.
2. Racket head drawn back in straight line to height from which ball is to be hit.
3. Racket head well back--hand back to right side, at least.

D. Eastern forehand grip.

II. Stroke

A. Body position.

1. Left foot in front.
2. Left shoulder toward net.
3. Weight shifted from back foot as ball is hit.
4. Slight knee flexion.

B. Arm and wrist.

1. Arm extended.
2. Arm far enough from body to allow freedom of shoulder swing.
3. Wrist locked.

C. Racket position.

1. Racket head above wrist.
2. Racket head carried in straight line from backswing.
3. Racket face brought flat against ball.
4. Ball hit off belt buckle.

III. Follow-through

A. Body position.

1. Weight shifted to left foot.
2. Left foot in front.
3. Back foot in contact with ground.
4. Slight flexion of left knee. Right knee may be extended.
5. Body rotation to left.

B. Arm and wrist.

1. Arm extended.
2. Wrist locked.
3. Extended right arm in abduction and right hand placed in left hand about shoulder high.

C. Racket position.

1. Racket head above wrist.
2. Racket face perpendicular to ground.
3. Racket head pointing above left net post at completion.
4. Racket brought back to "waiting" position after completion.

ELEMENTS OF BACKHAND DRIVE

I. Backswing

A. Body position.

1. Right foot in front.
2. Weight on left foot.
3. Slight knee flexion.
4. Body rotation to left.
5. Body rotation allows back to turn slightly toward net.
6. Look at ball over right shoulder.

B. Arm and wrist.

1. Arm extended.
2. Arm far enough from body to allow freedom of shoulder swing.
3. Wrist cocked (in abduction).

C. Racket position.

1. Racket head above wrist.
2. Racket head drawn back in straight line to height from which ball is to be hit.
3. Racket head well back--right hand to left leg, at least.

D. Eastern backhand grip.

II. Stroke

A. Body position.

1. Right foot in front.
2. Right shoulder toward intended flight of ball.
3. Weight shifted from back foot and body (rotation) "uncoils" as ball is hit.
4. Slight knee flexion.

B. Arm and wrist.

1. Arm extended.
2. Wrist snapped into adduction as stroke begins.
3. Arm far enough from body to allow freedom of shoulder swing.

C. Racket position.

1. Racket head above wrist.
2. Racket face brought flat against ball.
3. Racket head carried in straight line from backswing.
4. Ball hit on line with right foot.

III. Follow-through

A. Body position.

1. Right foot in front.
2. Weight shifted to right foot.
3. Back foot in contact with ground.
4. Slight body rotation to allow longer reach.
5. Slight flexion of right knee. Left knee may be extended.

B. Arm and wrist.

1. Arm extended.
2. Right arm in abduction with hand about shoulder high at completion of follow-through.
3. Near completion, extended arm in slight rotation to allow racket head to face somewhat downward (elbow rolls under).

C. Racket position.

1. Racket head above wrist.
2. Racket head points above right net post (approximately) at completion.
3. Racket face slightly downward at completion.
4. Racket brought back to "waiting" position after completion.