KINESTHESIS IN RELATION TO SKILL LEVEL IN

BASKETBALL, BOWLING AND TENNIS

by

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A Thesis Submitted to
the Faculty of the Graduate School at
The Woman's College of the University of North Carolina
in Partial Fulfillment
of the Requirements for the Degree
Master of Science in Physical Education

Greensboro
June, 1963

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ACKNOWLEDGMENTS

The writer wishes to extend sincere appreciation to Dr. Gail M. Hennis for her encouragement, interest and effort throughout the direction of this study, and for the support and guidance she offered during the writer's year of graduate study at the Woman's College.

Acknowledgment is also extended to the graduate students who so ably helped with the administering of the tests, and to the students who acted as subjects for this study.

The writer further acknowledges the members of the faculty of the Physical Education Department for the many challenging experiences of graduate study.

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CHAPTER I

INTRODUCTION

Man is a unique and highly complicated living being. Since time began, we have been striving to increase our knowledge of the structure and function of man. With each new discovery have come more unanswered questions. The nature of man's senses has offered many enigmas, for the highly intricate perceptivity of the eye, the magic hearing of the ear, and the mechanics involved in smelling, tasting, and touching have been the subject of extensive research.

Located in the neocortex is the least understood yet most important of our senses: the muscle sense, formally called the kinesthetic sense. This sense "provides the mind with its understanding of stretch, tension, movement, and the third dimension. . . Without the sensations that arise from activity in muscles and joints our 'inner world' of concepts would be flat and completely unreal."(17:10) Within this muscle sense lies the most important contribution of physical activity to the mind of man. Every movement we engage in, every tension in muscle, tendon, and joint contributes to the formation of concepts and ideas that are the building stones with which we construct our life of thought and action.

Individuals are always experiencing the use of the kinesthetic sense, whether they recognize it specifically or not. Some people can feel the exact amount of pressure and the intricateness of movement needed to knit without looking at their work, while others have to struggle through the movement watching every little bend of the finger and twist of the yarn. Some people can sense their degree of accuracy when executing a sport skill, while others do not know whether they are awkward or graceful.

The kinesthetic sense can be made to give us an accurate knowledge of the position of our bodies in space and of its movements. To develop a motor technique, and a fine discriminating kinesthetic sense to control it, is one of the solutions to a problem of physical education. "It is a process of discovery, analysis, and synthesis, and a perfecting, according to an intellectual ordering which demands the best efforts of both mind and body."[(6:90)] Through kinesthesis we sense errors in movement, and thus the mind becomes aware of them and makes corrections.

Scott[(15)] has stated that kinesthesis is a definite factor in the learning of movements. She has further commented that in spite of the fact that physical educators have recognized for years that the kinesthetic sense must have some relationship to motor performance, very little is known about how to identify the varying degrees of this sensory acuity. Kinesthesis has become a rising influence in the field of physical education during the past twenty years, as more and more research has been undertaken in the areas of measurement of kinesthesis, kinesthesis and motor learning, and kinesthesis and motor ability.

Many investigators have attempted to answer whether those who score highest on general motor ability tests and on skill tests possess a superior kinesthetic sense. The measures used in answering this question have varied considerably. Every kinesthesis battery has differed, and no valid and reliable measure of general kinesthesis has been developed. With each new piece of research in the area of measurement of kinesthesis we become more aware of the specificity and diversity of the kinesthetic sense.

Results of investigations have been inconclusive as far as a significant relationship between motor ability and kinesthesis, and skill level and kinesthesis. At this time no comparisons have been published between kinesthetic acuity and skill level in different physical activities. This study was undertaken with the objective of investigating kinesthesis in relation to skill level in basketball, bowling and tennis.

The author has felt that kinesthetic awareness provides a necessary ingredient for developing advanced skill level. However, she has questioned whether a relationship exists, and if it affects the development of skill in a variety of physical education activities. Do those who are highly skilled in basketball possess a keener kinesthetic sense than those highly skilled in bowling or tennis?

Though the functioning of the kinesthetic sense still remains partially unknown, the author feels that research in this area may lead to a better understanding of its nature. Findings may also lead to the development of teaching methods based upon scientific investigation. Physical educators who are aware of the many factors influencing motor learning, such as kinesthesis, are better able to effectively teach. It is important that their methods of instruction are adapted to both the needs of the students and the nature of the activity taught. It is for this reason that this study has been undertaken.

CHAPTER II

STATEMENT OF PROBLEM

The purpose of this study was to investigate the relationship between kinesthesis and the level of skill of three groups of subjects selected for their ability in basketball, bowling and tennis. A second purpose was to compare the differences of the three groups on their measures of kinesthetic sensitivity.

CHAPTER III

REVIEW OF LITERATURE

I. DEFINITION AND NATURE OF KINESTHESIS

Man knows the direction of his movements, he is aware of the position of his arms and legs, and he can "feel" his body in motion. Ensign[67], citing Dearborn, says that the kinesthetic sense is probably the earliest sense of animal life. It is distinguished from other sensations because its cause and effect are the same -- motion. This "sixth sense," a muscle sense, was not described until 1826 by Charles Bell. Since that time numerous definitions of what was later to be called the kinesthetic sense have been recorded. Physiologists and psychologists have defined kinesthesis as "a sensory property of the human being with implications for motor accuracy and precision, individual difference, emphatic appreciation, and even determination of neural normalcy."[49:325] Henry stated, "the term kinesthesis is defined as the perception or consciousness of one's own muscular responses."[35:177]

Numerous physical educators have delved into the nature of kinesthesis and have come forth with their definitions. Scott uses as her definition,

> Kinesthesis is . . . . the sense which enables us to determine the position of segments of the body, their rate, extent, and direction of movements, and the position of the entire body, and the characteristics of total body motion.[49:325]

Scott and French further describe kinesthesis by the following:

> Kinesthesis is defined here as that sense which enables the person to perceive the position of movement of the total body and of its parts. It is the basis for balance, both dynamic and static, for knowing the gradations of effort put into a movement, and for suplicating movements previously performed. Kinesthesis operates much as vision, in that the individual takes it for granted, is not really aware of the process or able to analyze what is happening. But like vision and the other senses there are individual variations in acuity of the sense and the way in which the individual becomes conscious of what he is seeing, feeling and the like.[16:390]

The stimuli pertinent to kinesthetic sensation are carried by special receptors and nerves just as the stimuli of vision are carried to neural centers on pathways. However, the quality of the sensation is only dimly experienced. Brown and Gilhousen emphasize the uniqueness of man's kinesthetic sense in the following which Henry has cited:

> Man is remarkably well endowed with kinesthetic receptors. No other animal can even approach the precision of timing and delicacy of control that man attains in playing a violin, or in expert drumming, or in dancing, or in walking a slack rope. We are in a class by ourselves when it comes to kinesthesis, and this is in spite of the fact that our awareness of kinesthetic sensitivity is not very good.[35:117]

Research on kinesthetic perception has been done primarily by psychologists and neuro-physiologists. Their recent studies have demonstrated that the kinesthetic preceptors are second only to the eye and ear in complexity and in richness of sensory information they convey. Metheny comments on some of their other findings.

> Psychologists who are studying the nature of human intelligence have come to recognize that all varieties of sensory perception are subject to the transformating process of human mentality, and recently they have identified kinesthess /Kinesthesis/ as one of the important sources of the knowledge and understanding that we call intelligence. Perhaps these

new findings that give us the encouragement we need to speak out about the meanings we have always known were inherent in our own movement experiences.(41:6)

Griffith, in describing the nature of the kinesthetic sense, states that it not only gives us

. . . an accurate knowledge of the position of our bodies in space and of its movements but of knowledge of special energies of the whole body, its tonus or its 'peppiness,' as well . . . these muscular sensations are a neglected aid in the whole process of acquiring skill.(5:54)

Scott says that the kinesthetic sense "is a definite factor in the learning of movements."(15:84)

Wilson has summarized that kinesthesis is responsible for:

1) Perception of own bodily movement, whether active or passive
2) Awareness of the position of the body parts and of the whole body
3) Ability to recognize, assume, and hold a specific position and/or force
4) Determination and distinction or weight and pressure
5) Awareness of the body in relation to its surroundings
6) Co-ordination of movement
7) Partial aid in maintenance of balance(78:2)

II. ANATOMICAL AND PHYSIOLOGICAL BASES OF KINESTHESIS

Out of common experience a person with his eyes closed knows the direction of a movement, active or passive, and is aware of the position of his arms and legs. Not until 1826 was this "sixth sense," a muscle sense, described by Charles Bell. "'Between the brain and the muscles,'" he said, "'there is a circle of nerves; one nerve conveys the influence from the brain to the muscle; the other gives the sense of the condition of the muscle to the brain.'"(14:315) The principal sensory end-organ of muscles was not fully described until 1892 by Sherrington and Ruffini. Two years later Sherrington showed that the muscular branches of nerves contain a high percentage of afferent fibers.

The kinesthetic receptors furnish the central nervous system with data regarding the position and movements of the limbs and other parts of the body. This enables the nervous centers to produce the coordination of muscular tensions necessary for efficient movements. In combination with the sensory organs, they enable the body to make the changes in position necessary to maintain balance and to execute body movements.[14]

The kinesthetic receptors are located within the organism away from the direct influences of external stimuli. The author has made no attempt to discuss the vestibular receptors of the nonauditory labyrinth. These along with the kinesthetic receptors constitute the proprioceptors. Morgan[10] has described the proprioceptors as differing from the exteroceptors in that: (1) they are stimulated by the action of the body itself, whereas the exteroceptors are activated by stimulus conditions in the organism's environment, (2) proprioceptive stimulation is always within the organism, guiding it in its every movement in constrast to the intermittent and occasional action of the exteroceptive stimuli, (3) seldom is one clearly aware of the proprioceptive activity going on within him while the functioning of the exteroceptive systems is usually present in vivid detail, and (4) with respect to the adjustment of the organism, the reflexive and postural behavior with which proprioception is closely related constitutes the specific adjustment controlled exteroceptively.

Neurosensory Mechanisms of Kinesthesis

Receptors. There are three main types of proprioceptive receptors besides the free nerve endings in blood vessels. These kinesthetic end organs may be distinguished: the muscle spindle, the Golgi tendon organ, and the Pacinian corpuscle.

The muscle spindle consists of a complicated structure of muscle fibers innervated by sensory nerve endings which are enveloped in a tissue fluid and a capsule of connective tissue. Within the muscle spindle are nerve endings of two types. The annulo-spiral endings, which are terminals of large myelinated A type fibers, are arranged spirally around the muscle fibers of the muscle spindle; differing from these are the flower-spray endings, which are associated with somewhat smaller myelinated fibers and have spraylike endings. The muscle spindles are stimulated by stretch of the muscle fibers, and are therefore called stretch afferents. Contraction tends to decrease their rate of discharge.[10][13]

Golgi tendon organs, located near the distal ends of muscle fibers in the vicinity of the juncture of muscle fibers with the tendons which attach muscle to bone, are also composed of a bundle of fibers surrounded by lymph and enclosed in a fibrous capsule. Innervating the Golgi organs are afferent nerve endings, called tendon endings, which are stimulated by either an increase or decrease of tension at the tendon-muscle juncture. These tendon endings are the principal organs for recording muscle contraction. Rasch and Burke state,

> Since the muscle spindles respond only to stretching, the nervous system is able to distinguish between stretching and contracting according to whether both the spindles and Golgi organs are stimulated (stretching) or only the Golgi organs are stimulated (contraction). (13:102)

The Pacinian corpuscles are oval, laminated bodies of fibrous tissue which are distributed widely in the body, being found commonly in the sheaths of tendons and muscles, in the linings or various organs of the body, and in the subcutaneous tissue. They are organs of deep pressure sensitivity and are activated by deformation of the body tissue. (10) (13)

As kinesthetic receptors, the above end organs are associated with the large myelinated fibers, although there are systematic differences in respect to fiber size and conduction velocity among the various receptors. Morgan(10), Rasch and Burke(13) and Best and Taylor(1) also consider free nerve endings as kinesthetic receptors. As far as muscles are concerned, they seem to be restricted to the blood vessels serving the muscles and to the sheaths covering muscles and tendons.

<u>Nerve Fibers</u>. Experimentation with measurement of nervous impulses in kinesthetic nerves has lead to the delineation of four types of fibers. They are associated with the different receptors, and are designated by the letters A_1, A_2, B and C. The A fibers are associated with the muscles spindles. B fibers serve the Golgi tendon organs and C fibers serve the Pacinian corpuscles. It can be assumed that in kinesthetic fibers the small and mostly unmyelinated fibers mediate pain; but it is probable that most of them are distributed to blood vessels and to sheaths of muscle and tendons rather than directly to muscle

fibers.[10]

Neural Centers and Pathways. There are relationships between neural centers and pathways of the kinesthetic and cutaneous systems. The kinesthetic nerve fibers, together with those from the skin come to the spinal cord by way of the dorsal ganglia and dorsal roots. Most of the kinesthetic fibers enter the cord by way of the medial filament and pass directly into the dorsal columns. Some of these fibers, instead of entering the dorsal columns, terminate in the gray matter of the cord.

> Other kinesthetic fibers of the dorsal root terminate upon cells in the gray matter whose axonal branches ascend in the spinothalamic or spinocerebellar tracts. These latter . . . are important elements in the integration of kinesthetic and vestibular impulses in the motor functions of the cerebellum.[10:287]

The fibers of the trigeminal cranial nerve going to the mesencephalic neucleus near the pons are most important in kinesthesis. From here the fibers ascend to the medial part of the posteroventral nucleus of the thalamus, and thence projections lead to the somesthetic cortex.[10]

Neural Basis of Kinesthetic Discrimination

Kinesthetic fibers enter the cord and ascend in the dorsal tracts on the same side; lesions in the spinal cord therefore interfere with sensitivity on the same side of the body. Crossing of the kinesthetic pathways occurs above the cuneate and gracile nuclei of the medulla, and there it appears to be complete. The role of the cortex in kinesthesis is somewhat more complex than in that of lower centers because parts of the cortex other than the primary projection areas are concerned in kinesthetic functions.[10]

Quantitative measurements of the effects of brain lesions in man have been made in the case of kinesthetic weight discrimination. Two patients had surgical lesions, one in the anterior part of the parietal lobe and the other in the posterior parietal area. Both showed pronounced and lasting deficit to discriminate weight. These results agree with the findings in experimentation with the monkey and chimpanzee.[10]

In summary, from the end organs of the kinesthetic receptors, afferent fibers carry impulses to the centers in the brain, which send out impulses along efferent fibers to the muscles. There is thus a circle of nerve fibers between the brain and the muscles, one fiber giving the sense of the condition of the muscle to the brain and another carrying the impulse from the brain to the muscle. Through these one is conscious of the condition of the muscles. This enables coordination of the contractions of harmonious groups in order to produce voluntary movements.[7]

III. RELATIONSHIP OF KINESTHESIS TO MOTOR LEARNING

General

With kinesthesis being defined as the muscle sense, it follows that the kinesthetic sense would be very closely related to motor learning. Stevens[76], Ensign[67], Scott[15], Wells[19] and others[8][12][36][45][58] have emphasized the importance of kinesthetic perception in learning and perfecting motor skills. Stevens stated:

> Kinesthesis is most pertinent to the acquisition of motor skills since the awareness of movement is essential to successful performance. Through the kinesthetic sense it is possible to bring movement into consciousness, and thus realized, we are able to control and make adjustments. This fact underlies the learning process in purposive movement, and conditions any improvement. It is the central fact underlying the teacher-learning situation of motor skill common to physical education.[76:2]

Ensign[67], too, stressed the importance of awareness of the body during the learning stages of a skill. That the acquisition of skill will probably take place much more rapidly and upon firmer roots, for movement that is consciously recognized, analyzed, and directed is understood. Physical education is striving to develop this type of an understanding of the body. Scott says, "development of kinesthetic patterns is a direct by-product of activity and an essential factor in the learning of motor skills."[15:352] Kinesthesis is the basis for learning motor acts so that they may be performed most efficiently, for retaining complexly coordinated skills over any length of time, for most of the activities of the blind, for emphathetic understanding and appreciation of the performance of others, and for successful performance of balancing activities. Wells[19] emphasized that awareness of position or movement and of intensity of muscular action is an important aspect in learning new skills. The memory of former sensations and the consciousness of present ones in the performance of a skill help us to judge the correctness of our movements.

Much of one's ability to learn a skill quickly depends upon his kinesthetic receptivity. The smooth functioning of a well-learned motor skill no doubt has in it a large kinesthetic element. It has been assumed that each movement in such a skill furnishes the stimulus for succeeding movements, and that the smooth succession of movements is due to the close chaining of movements made possible by kinesthetic stimuli.(36) Kinesthetic sensations also have carry over value for later learning. When an individual attempts an activity which is not too complex and which has certain elements that are within his experience, he understands the performance better because of the similarity. Teachers structure their presentations to create the most effective learning conditions. The success of the visual and oral presentation depends upon the learner's experience and feeling for that or similar activities. "This, then, is the real reason for careful progression in teaching skill. It is wasteful of time to teach a complex skill if most of the essential parts have not already been experienced in some form."(15:354)

Ragsdale has done a great deal of study in the field of motor learning. Quoting from his chapter in The Forty-Ninth Yearbook of the National Society of the Study of Education, "Motor learning is basically perceptual, especially kinesthetic."(12:88) He stated that blindfolded practice makes for greater dependence on the kinesthetic sense, and that skills should be related to previously known skills whenever possible, thus one can build on familiar kinesthetic patterns. Ragsdale further stated that motor learning is always perceptual, cognitive, as well as social, and that it is a gross error to regard it as merely a mechanical process. Kinesthetic perception is fundamental, but visual, auditory and tactual impressions are also important. These sensory components must be ordered, interpreted and acted upon.

Oberteuffer[11] mentioned the value of the kinesthetic sense in learning physical skills. He stressed that learning in physical education is total and does not rely only upon auditory and visual stimuli. This type of learning involves doing and feeling as well as seeing and hearing. The "seeing and doing studies" point out that learning is more efficient if the learner feels the experience going on within himself. The individual with a keen kinesthetic sense can "feel" each shot or stroke and "sense" the smoothness and accuracy of the muscular efforts. "Getting the feeling 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."[11:206] From the awkward, inept and confused movements gradually one feels what he is doing and thus a kinesthetic understanding of the whole is developed. From then on improvement is usually rapid.

In his study of tests of kinesthesis, Wiebe mentioned the following relationships of kinesthesis to physical education:

1. The 'position sense,' kinesthesis, is the sense of the material with which physical education primarily concerns itself, (i.e. the use of muscles in performing motor activities).
2. The functions ascribed to kinesthesis - coordination of body movements, development of skills, locomotion, posture, body control, manipulation, balance, and appreciation of weights and forces - are important elements in teaching skills.
3. The components ascribed to kinesthesis - perception of movement, tension or resistance, position, space perception, balance, relaxation, and effort - are familiar and oft-used concepts of physical education.[58:222]

McCloy[40], in a preliminary study of the factors of motor educability, determined kinesthetic sensitivity and control to be factors. Hanley has stressed that to appreciate kinesthetic sensations, an ability to discriminate between kinesthetic movements is necessary.

> The higher the degree of discrimination possessed, the greater the skill that may be attained. Through the contracting and releasing muscles, the student learns just when the parts of the body are in the proper position to complete a successful movement. Then, as a definite rhythm is established and all extra movements are eliminated, the student realizes that only a certain set of coordinated muscles is being used . . . .[33:367]

One of the first published studies actually concerning kinesthesis and motor learning in physical education was reported by Lafuze[39]. She administered kinesthesis tests, motor ability tests and skill tests before and after a traditional training period. The subjects were in four skill clinic classes taught for women who scored in the lower quartile of the initial Scott Motor Ability Test given to all entering freshmen at the State University of Iowa. Two classes had the tests after an eight week instructional unit, while the other two classes were given the tests after sixteen weeks of instruction. No consistent changes in any of the measures appeared. It was felt that the kinesthesis tests needed to be refined or changed. The question arose as to whether practicing a skill should improve a basic sensory capacity. Lafuze did not find that these four classes in the lower quartile of the Scott tests scored significantly lower than those persons in the upper quartile on the kinesthesis battery.

Phillips and Summers[45], studying the relation of kinesthetic perception and motor learning, concluded that there is a relationship between motor learning and positional measures of kinesthesis, that the kinesthetic sense is more important in the early stages of learning a motor skill than in the later, and that there are real differences in kinesthetic perceptivity between the preferred and non-preferred arms. These results were based upon the scores of 115 college women on twelve positional measures of kinesthesis. The women were classified as fast or slow learners on the basis of the improvement shown during twenty-four class periods of bowling. Differences between the mean kinesthetic scores were tested for the fast and slow learning groups and for the entire group between preferred and non-preferred arms.

Learning Specific Skills

Slowly an understanding of the nature of the kinesthetic sense is being developed, and with this knowledge applications are being made to teaching techniques. The kinesthetic method is becoming more and more refined. With each new study in this area of motor learning we become more aware of the effectiveness of emphasizing kinesthetic perception.

The kinesthetic method has been compared with other methods of instruction in learning skills in golf, bowling and basketball. One of the first studies that offered substantial evidence was conducted by Phillips. His purposes were to learn more about the nature of kinesthesis,

> . . . to learn whether the ability to perceive bodily movement and tension manifested in the kinesthetic tests used in the study depends upon a general factor or whether it is specific to the particular stimulus pattern involved in the tests. (44:571)

and to determine if there were any predictive values between the tests which might be related to performance in the two simulated golf skills studied. The perceptuo-motor skills analyzed were the putt and the drive. Phillips found correlations of .505 and .422 between a battery of four tests of kinesthesis and putting and driving scores in golf following a period of instruction. He concluded that there was a low but definitely positive relationship between kinesthesis and successful performance in the early stages of learning perceptuo-motor skills and that there seems to be no basis for the phrase "general kinesthetic sensitivity and control."

Griffith's[15] study was actually the first utilizing the kinesthetic method. He emphasized the dependence upon kinesthetic feeling and its place in learning the golf drive. The control group was taught by the usual method of watching the ball and receiving verbal instructions. The experimental group, which was blindfolded, was told what to do and what happened to the ball on each swing. The latter group made greater errors at first, but eventually secured superior results by depending only upon the feeling of the performance. No statistics were reported to determine the significance of the results, and there were only six subjects in each group.

Hanley[33], Coady[45], and Rollo[46] have also been concerned with the use of the kinesthetic method in teaching golf. Hanley stressed that, "an immediate effort should be made to instill . . . a consciousness of a mental pattern, not built on imitation alone, but actually constructed on the kinesthetic sensations resulting from trial and error performance."[33:367] Coady found that golf skills were not significantly improved when an awareness of the kinesthetic sense was emphasized. The most recent golf study was carried out by Rollo in 1959. The procedure was similar to that of Griffith twenty years earlier. The traditional group and the kinesthetic group were equated on a battery of kinesthetic tests at the start of the experiment. At the end of the unit the subjects, college women, were given tests using the driver, the five and eight irons, and the putter. With the two per cent level of significance chosen, there was no advantage of either method over the other.

McGrath[45], Halverson[69] and Hertz[70], respectively performed similar investigations with methods of teaching basketball skills. McGrath found that the kinesthetic method had no significant advantage over the traditional method in teaching free-throw shooting. Halverson compared the effectiveness of teaching the one hand push shot by the three methods: mental practice, overt practice, and kinesthetic awareness. This last method placed emphasis on kinesthetic memory of the shot and suggested recall of range of movement, the amount of force, the feeling of quick extension and feel of balance on forward foot after release. She concluded that the kinesthetic method was as effective in the development of motor skills as present methods. Using similar groups, Hertz concluded that any of the three methods applied to freshman high school boys would result in improved foul shooting ability. However, none of the groups showed significant improvement.

Waterland compared the effects of teaching beginners to bowl through overt practice, mental practice and kinesthetic perception. The group using the latter method concentrated on developing a movement pattern which would send the ball from the foul line to the area of the head pin within 2.8 seconds. "The time was set to help students develop a keen kinesthetic perception of amount of force, direction and position necessary for a successful movement pattern."(57:24) There was no significant difference between the first ball scores for the three groups, but the kinesthetic awareness and mental practice groups preceding overt performance had a greater gain in final time than the overt practice group.

The kinesthetic, visual aids and conventional methods in teaching body mechanics were compared by Tate.(55) The kinesthetic method accentuated the appeal to one's conscious awareness of position and movement relations. Cues were used to assist in recognizing sensations coming from the muscles, tendons, joints and pressure from the sole of the foot. All groups made significant gains in skill. In both static and dynamic posture the visual aids group measured best and the control group was slightly better than the kinesthetic. In dynamic motor skills the visual aids group was significantly better than the kinesthetic group and superior to the controlled group.

Smith(52) studied the physical traits and abilities of elementary school children in relation to their ability to learn a ball bounce and ball toss motor skill. She found significant differences between positional measures of kinesthesis of fast-learning and slow-learning groups on the two motor skills. Linday(45) reported a low positive correlation between kinesthetic sense and learning a motor skill involving rolling a ball at a target.

An extensive study was carried out by Roloff[47][73] to investigate the relationship between kinesthesis and the learning rate of college women in achieving certain motor skills. After developing a battery of tests measuring kinesthesis, the battery was used in determining the effectiveness of the use of the kinesthetic approach as a teaching method. Two hundred college women were subjects for Roloff's study. Four skill clinic classes and four bowling classes were used. Two classes in each activity were taught by the conventional method and two classes were taught by methods attempting to stress a kinesthetic approach. The experimental groups had more short demonstrations, visual aids, and drills with the eyes closed. Being able to "feel" the movement was emphasized. There was also one tennis class taught by this kinesthetic method. It was concluded that there was no statistically significant proof that either of the teaching methods used was better than the other. "In accepting the hypothesis that a kinesthetic approach to the teaching of certain motor skills is of value, it is concluded that there needs to be further refinement of the specific methods of teaching."[73:49]

It is believed that kinesthesis holds part of the answer to the secret of individual differences in motor accomplishment.

> It can give the physical educator a tool with which to instruct and serve as an aid to understanding, guiding and motivating individuals. Method might be so improved as to lead to considerably greater accomplishment and development of an ability in the learner to be more independent and more capable of self-directing his learning in the future.[49:324, 325]

IV. MEASUREMENT OF KINESTHESIS

General Background

Even though physical educators have recognized for years that the kinesthetic sense must have relationship to motor performance, they really know very little about how to identify the varying degrees of this sensory acuity. Efforts at measurement of kinesthesis have been very sporadic and not too successful. Scott emphasized that the problem which faces most investigators is defining and identifying kinesthesis. This is essential as a starting point in measurement, but the lack of facts make it almost impossible. "It /measurement of kinesthesis/ represents a challenging type of investigation, but in analogy is a situation of trying to lift one's self by the boots without even the boot straps to grasp."(49:324)

Attempts at measurement of kinesthesis have in the past been somewhat disappointing. The main conclusion of all the earlier studies resulted in the belief that it is possible that kinesthesis is a complex rather than a unitary thing. It is quite unlikely that it involves several functions that are relatively unrelated insofar as individual differences are concerned. Furthermore, recent studies have led to the belief that kinesthesis may not be thought of as a general sense but as specific to the part of the body being tested and the nature of the test.

Review of Measurement Studies

The earlier investigations were directed toward validating empirically selected test items. These have opened the way for the later studies of factor analysis, correlation with learning rate, effects of practice, and the relationship to general motor ability and to ability in specific skills.

Wettstone drew together a group of tests and measurements in an attempt to determine how well they function in testing gymnastic ability. One of the eleven items considered dealt with measurement of kinesthesis. Wettstone stated, "though the test used to measure this ability is relatively unknown and has not appeared in physical education literature, it is a simple one."(59:118) The sections of the test were arranged to measure the relationship of one part of the body to another, the relationship of one part of the body to an object nearby and the relationship of the gross movements of the body to positions in the air on the flying rings. The battery consisted of finger pointing, holding the arms in certain positions, target pointing, and manipulating the body into a vertical and a horizontal position on the rings. The methods of scoring were very simple and subject to error. Kinesthetic sense measures, however, were excluded when the final battery was chosen.

Stevens[76] performed the first of the more recent and scientifically controlled attempts at measurement of kinesthesis. She wanted to find out if there were good items that would differentiate between individuals in terms of their kinesthetic sensitivity, if individuals who are trained in motor movements show a more highly developed kinesthetic sense than the untrained, and if the highly skilled performers show a higher developed kinesthetic sense than do the less skilled performers who have had comparatively the same amount of motor training. The study was based on the assumption that individuals vary in their ability to perceive body positions, and the force and extent of muscular contraction. In developing her kinesthesis battery, Stevens used thirty-six tests selected from a survey of all kinesthesis tests. They were administered to a small group, and the results were intercorrelated. Certain tests were T-scored and combined into a battery to establish a criterion measure of kinesthesis. Correlations between the criterion measure and each of the individual tests it included were found. Predictive indices of kinesthesis were determined once multiple correlations and multiple regression equations were found. The Doolittle Method was used in locating the beta coefficients which provided the best weightings. The six item battery included: sidearm 90^{o} (R), sidearm 90^{o} (L), arm pull 15 lbs. (R), arm pull 15 lbs. (L), arm lift 130^{o} (R), leg force 20 lbs. (L), and had a multiple correlation of .923. The five item battery had a correlation coefficient of .912. It excluded the leg force 20 lbs. (L). The four item battery further deleted the sidearm 90^{o} (L), and the three item battery was composed of only sidearm 90^{o} (R), arm pull 15 lbs. (L), and arm lift 130^{o} (R). Their multiple correlation coefficients were .892 and .837, respectively.

In 1951 Wiebe(58) studied the nature of twenty-one different tests of kinesthesis which were administered to fifteen college varsity athletes and fifteen college men who had never earned letters in high school varsity sports. Reliabilities, validities, and intercorrelations were calculated. Although fifteen of the tests had reliability coefficients which could warrant their use as testing instruments, none had a validity coefficient high enough to warrant its use as a single test. The low intercorrelations between the tests indicated the specificity of kinesthetic sensitivity. Wiebe found the athletes significantly superior to the non-athletes in kinesthetic response. Many of the tests used in this investigation were performed only on the dominant side. The combination of tests which appeared to measure kinesthesis in college men best included balance lengthwise, leg raise, vertical space and separate feet.

A preliminary step in the previously mentioned study done by Roloff[47][73] was that of developing a battery of tests measuring kinesthesis. The reliabilities of twelve tests selected from Young, Fisher, Scott, and the Victory Through Fitness report were computed. T-scores were set up and from these results eight tests were selected for use in her study. Each of the eight tests were intercorrelated with the other seven and reliabilities were determined. Validities were computed on each test using the T-score of all eight tests as the criterion. Multiple correlations and the Doolittle Method were used to determine the best set of items. The battery of tests recommended as a measure of kinesthesis in college women included balance stick, arm raising, weight shifting, and arm circling. The regression equation used for this study was: .75 balance stick - arm raising - weight shifting + 4.7 arm circling + 50. The obtained coefficient of multiple correlation was .88.

Witte[3][79], Russell[75], and Wiebe[77] all used the factor analysis technique in studying measures of kinesthesis. In Witte's attempt to explore the nature of several tests designed to measure kinesthesis, intercorrelations between these tests were analyzed in an effort to answer the following questions: "(a) what are the factors basic to the kinesthetic sense, (b) which of the tests is the best measure of each factor, and (c) what is the factorial composition of each of the tests?"[3:n.p.] The identification of seven factors basic to the thirty tests studied emphasized that kinesthesis cannot be thought of as a general trait. The factors identified were: force of muscular contraction of the arm, leg positioning, arm positioning for short arm movements on the vertical plane, arm positioning in long arm movements on the vertical plane, extent and force of muscular contraction of the arm on the horizontal plane, arm positioning on the horizontal plane and force of muscular contraction of the leg.

A number of factors emerging in Russell's study "sustain the hypothesis that kinesthesis can be divided into distinguishable functions that do not operate in all tasks that involve responding to kinesthetic stimuli."[75:55] A preliminary factor analysis of the intercorrelations of fifteen tests of kinesthesis administered by Scott was performed. These were the items which made up three batteries administered at the State University of Iowa during 1952, 1953, and 1954. Intercorrelations between the tests in each of the batteries were analyzed by the Thurstone multiple group factoring technique. The possibility of the existence of the following factors was tentatively suggested: arm positioning on the horizontal plane, awareness of the extent of muscular contraction in the arm, a factor that operates in arm movements, balance, leg positioning, orientation of the body in space, and arm positioning on the vertical plane.

Acting on Russell's suggestion that further investigation was needed to clarify the nature of the factors in her study, Wiebe(77) utilized a factor analysis technique to determine the nature of a battery of tests of kinesthesis. The selection of the battery was governed by the factors which were hypothesized by the author to be common to the tests in the battery. The factors were determined by studies in anatomy and physiology and by previous analyses of tests of kinesthesis and tests of balance. Eight common factors emerged when the multiple group method of factoring was carried out on a battery of forty-four measures. The four kinesthetic factors isolated were in partial agreement with Wiebe's hypothesis. They were: arm static function, kinesthetic response in balance, thigh-leg static function, and arm dynamic function. Three reference factors - strength, size and sports ability - all appeared, along with the eighth factor, balance. Eight specific tests were suggested as the best reference tests.

Scott's(49) study was an attempt to establish a measurement of kinesthesis. A group of one hundred college women were given twenty-eight measures of kinesthesis and two of motor ability. Later, a second group was given sixteen measures of kinesthesis. An analysis was made of the quality of the test items and of the interrelationship of the tests given both groups.

The low interrelationship found led to the assumption of specificity of function. The reliabilities of most of the tests were adequate. There was no single item related high enough to the criteria employed to be useful alone as a measure of kinesthesis, but several combinations gave fair validity. The combination of low intercorrelations and the above led to the conclusion that kinesthesis is composed of a series of specific functions.

A related study was carried out by Clapper(65) in an attempt to measure kinesthetic responses at the junior and senior high school level. It was possible to make measurements with approximately the same degree of validity and reliability as at the college level. It appeared that there might be a measurable growth factor related to some, but not all, types of activities which are thought to be measures of kinesthesis. Other findings from her study indicated that the relationship between intelligence and kinesthesis was inconclusive and that there was a significant relationship between a battery of kinesthetic tests and the ease and speed of motor learning as rated by teachers. This latter relationship was insignificant in most cases when the tests were considered individually.

Studies by Chernikoff and Taylor(23), Henry(35), Slater-Hammel(50)(51), and Wilkinson(61) have dealt with different aspects in the measurement of kinesthesis. Chernikoff and Taylor's study tried to determine the reaction-time to a kinesthetic stimulus initiated by suddenly dropping the subject's splinted arm which was held horizontally by an electromagnet. The ultimate purpose was to determine the role of kinesthesis in the control of precise hand

and arm movements. No findings concerning this relationship were given; however, the method used for measuring kinesthetic reaction-time proved less complicated than previous methods.

Henry[35] considered kinesthesis as one of the most vital areas for physical education research. He hypothesized that accurate kinesthetic adjustment is possible in the absence of perceptual discrimination. Two types of kinesthetic adjustment were studied with respect to accuracy of response. Data collected from twelve male subjects showed a fairly close relationship between the adjustment and perception measures.

Slater-Hammel's[50] earlier study was a comparison of reaction-time measures to a visual stimulus and arm movement. The actual reaction-times for the two were compared as were the different measures for groups of liberal arts majors, varsity athletes, physical education majors, and music majors. Analysis of the data revealed that a moderate relationship existed between the two measures. Significant differences were found in the reaction-times among the groups. Later[51] he described a technique for using muscle potential changes as a measure of the kinesthetic perception of muscular force. This method required no tactical stimuli of any type, thus the body part under investigation was to have no forceful contact with objects in the physical world. The performance studied involved a stituation in which the subjects were given practice in contracting the triceps brachii at an intensity needed to generate potentials of approximately 125 microvolts. After practice, the subjects tried to reproduce the same muscular force as measured by muscular potential out-put. Measures on physical education majors and liberal arts majors revealed positive constant errors for both groups, and that the differences in variable errors between sexes and groups were not significant.

Reaction-time measures to a kinesthetic and visual stimulus for fifty non-athletes and one hundred varsity athletes were compared by Wilkinson.[61] The sudden displacement of the subject's supported arm served as the kinesthetic stimulus, and the lighting of a neon glow lamp was the visual stimulus. Results of measures showed that the kinesthetic stimulus produced a significantly faster reaction than did the visual stimulus. The athletes had a significantly better reaction-time, with wrestlers being the fastest.

Research in the area of measurement of kinesthesis has revealed a great deal about the nature of the kinesthetic sense. All findings point toward specificity and diversity of the component factors of kinesthesis. Witte, Russell and Wiebe attempted investigations of kinesthesis through the use of factor analysis. A wide variety of tests were suggested in the literature. Stevens, Roloff and Wiebe developed batteries of tests for the purpose of predicting kinesthetic discrimination. The major shortcoming of many of the investigations was an inadequate number of subjects.

V. RELATIONSHIP OF KINESTHESIS TO MOTOR ABILITY

Most of the definitions of kinesthesis suggest a close relationship with motor ability. When a person can perceive his own motor patterns and positions and has developed the ability to participate emphatically when others are "doing, " he can learn more quickly and recognize motor problems readily. This acuity aids in gaining skill, for a person who has a keen kinesthetic sense will demonstrate greater accomplishments than one who lacks this acuity.[16]

General Motor Ability

Five investigators, all working with women, have reported on the relationship found between measures of kinesthesis and tests of general motor ability. Young[64], Fisher[68], and Stevens[76] found either no relationship or a very low relationship present. More recent studies have produced differing results. Norrie[72] found that students rated as "good" and "poor" in general motor performance differed significantly in their kinesthetic judgment, particularly in those phases concerned with force control and balance. Roloff[47][73] reported a correlation of .43 between a battery of four tests of kinesthesis and scores on the Scott Motor Ability Test.

Young's purpose was to study kinesthesis in relation to selected movements commonly used in gymnastic and sport activities and to determine the relationship of kinesthesis to general motor ability. Thirty-seven physical education majors randomly selected from all classes served as subjects. A battery of nineteen tests of general kinesthesis, most of which were devised for this study, was administered to the subjects. Only two tests, the arm raise sideward 45^{o} and the balance test correlated significantly with the criterion of general motor ability. The coefficient of correlation obtained led the author to believe that there was no real relationship between the tests of kinesthesis, as set up for this study, and the Scott Motor Ability Test. It was concluded that the tests failed to achieve desired results. However, the total score criterion, which was a composite of scores of tests set up to measure kinesthesis, two general motor ability scores, and "the combination score of the tests of throwing, kicking, and hitting which were believed to be representative of movements most commonly used in sports activities, "(64:280) gave significant correlations with seven different test items including arm and leg positions, a dynamometer test, and a balance test.

Fisher's(68) study dealt with the relationship of kinesthesis to general motor ability and to general motor capacity in high school girls. She also had the problem of finding tests to measure kinesthesis. Her battery contained tests from Young, and from the Victory Through Fitness report, and tests she devised. The reliabilities, validities, and correlations were figured, with the following conclusions being reported: 1) the reliability coefficients were for the most part very high, 2) the correlations between the kinesthetic tests and those of general motor ability and capacity were positive and low, but close to the point of significance, thus it would seem apparent that these measures have something in common, and 3) the results were consistent with Young's study.

Stevens(76) was concerned with comparing the kinesthetic discrimination of two extreme groups as determined by scores on the Scott Motor Ability Test. One group measured high and one group measured low. The groups, which were equated according to their previous motor training and class in college, contained a total of forty physical education majors and one hundred non-majors.

It was found that the individuals who were trained in motor movements or who had more motor experience showed a more highly developed kinesthetic sense than did those who were untrained, and when motor training was held constant, those who scored highest on the Scott Motor Ability Test did not show a more highly developed kinesthetic sense than those scoring low on the Scott test.

It was hypothesized by Norrie[(72)] that a positive relationship exists between kinesthetic awareness and motor performance. The subjects were chosen on the basis of their ability to learn and perform skills from a group of four hundred students taking physical education at the University of California. There was a "good" group and a "poor" group each containing thirty members. A battery of seven measures of kinesthesis, containing arm sideward 90°, balance lengthwise, target toss, leg raise 60°, grip strength, finger touching, and a punchboard test, was given both groups. After reliabilities were computed the Chi-square technique was used to determine the significance of the differences between the groups. There was a significant difference found between the two groups in all of the tests except arm raising and finger touching. The three tests: target toss distant component, balance and punchboard test, showed as high a relationship to motor performance as any combination of four or five. "From the results it seems that balance and control and perception of differences in amount of force are important in differentiating between good and poor performers."[(72:26)] It was concluded that there was a significant positive relationship between measures of kinesthesis and motor performance.

Determining if a relationship exists between kinesthesis and general motor ability was one of the problems inherent in Roloff's[47] [73] study. She administered the Scott Motor Ability Test and a battery of four kinesthesis tests to nine physical education classes at the State University of Iowa at the beginning of a semester and again during the last week of the course. The correlation of the kinesthesis scores, determined by the previously mentioned regression equation, with the Scott test was .43. This correlation was found to be significant at better than the one per cent level. The relationship found by Roloff was higher than any heretofore mentioned.

Specific Skills

Numerous studies have further attempted to explore relationships that might exist between kinesthesis and physical performance and sport skills. In 1939, Bass[21] analyzed the components of nineteen tests of semi-circular canal function and static and dynamic balance. She found visual, kinesthetic and tactual factors all significant in static balance and that an individual uses his kinesthetic mechanism less when the eyes are opened than closed. A later study by White[60] concerned ataxia and its relation to physical fitness. Boys with superior athletic ability, poor athletic ability and those with medical restrictions were the subjects. The restricted boys and the boys with low skill had significantly poorer postural integrity than the athletic group. It was believed that postural steadiness might have some relation to the kinesthetic sensations involved in balance. However, during the testing the subjects could use visual cues because they were not blindfolded. Wells stated, "the kinesthetic sense would seem to be a vital factor in the mechanism for establishing and adjusting postural patterns, but this has not yet been demonstrated."[19:356]

Mumby[43], studying kinesthetic acuity and balance in relation to wrestling ability, found that a significant relationship exists between accuracy of adjustment to varying pressures and wrestling ability. He also concluded that an individual's ability to maintain constant muscular pressure under a changing dynamic condition was significantly related to wrestling ability as subjectively rated.

Greenlee[32] found a significant positive relationship between dynamic balance and bowling performance. The data used were computed from the average of the last six games bowled in an eight-week course and scores on tests of strength, static and dynamic balance, and various measures of kinesthesis. There were 122 beginning bowlers as subjects.

Two of the most recent studies were done by Roney[74] and Stoner[54]. Roney's main purpose was to compare the ability to perceive muscle contraction while studying the relation between kinesthesis and relaxation. She also attempted to determine whether or not the skill of relaxing could be taught and if kinesthesis might be a factor in learning to relax. Scores on six measures of kinesthesis were converted to T-scores and combined and then correlated with the relaxation measures. There was a slight relationship between total kinesthesis and total relaxation in the initial testing. The experimental group was given instruction in relaxation while the controlled group was not. It was reported that kinesthesis as measured in this study did not improve in either group and thus she concluded that it was not a factor in learning to relax.

Stoner[54] gave the Scott Motor Ability Test, a pronotion-supination test, a push-pull test, and a complex coordination sequence to eighty subjects randomly selected from a population of 585 college women enrolled in physical education classes. Some of the correlations between motor ability items, kinesthesis tests, and coordination trials were statistically significant, but none were high enough for predictive purposes.

A study was just reported by Witte[62] to investigate the relationship of kinesthetic perception to ball rolling accuracy for forty-seven boys and girls ages seven to nine. The four kinesthesis tests, which were done with the subjects blindfolded, all measured arm positioning. The boys were significantly better than the girls in ball rolling, but the differences in kinesthetic perception were not significant. The investigator found a correlation of .2832, indicating that no real relationship existed.

Investigations into relationship which might exist between specific skills and kinesthesis are becoming more common. Hart[34] attempted to determine if archery ability was related to certain abilities and characteristics, one of which was kinesthetic sensitivity. Correlations between the measures of kinesthesis and the criterion score, as received on a Columbia Round, indicated no significant relationship. There was a low, but significant relationship found between kinesthesis and strength.

Ikeda(37) concluded that there was no significant relationship between wrist flexibility, kinesthesis, or agility and badminton playing ability. This was reported after comparing scores on a series of tests including wrist flexibility, shuttle race, and measures of kinesthesis with results on the badminton volley and clear tests. The tests were administered to seventy-two women students during the last two weeks of an eight-week badminton unit.

The most recent study in this area was done by Zimmerman(80) in 1961. She investigated the relationship of kinesthesis to high and low levels of basketball ability. There were twenty-six highly skilled basketball players, and twenty-three unskilled players, all college women, used as subjects. One group was selected on the basis of scores on skill tests and ratings given by instructors for class participation; the other, on the basis of participation in the extramural program. It was reported that a low but significant relationship existed between the total kinesthesis score and the level of basketball performance as indicated by the sum of the T-scores on the three basketball skill tests. The kinesthesis score was computed by combining the T-scores on the twelve kinesthesis tests used: balance stick, balance leap, arm force, leg force, leg raising, arm raising, horizontal lines, ball balance, broad jump specified, weight shifting, arm circling and arm swinging. The jump and reach test, diagonal wall pass, and half-minute shooting test were used in computing basketball ability. It was concluded that a slightly keener sense was possessed by the highly skilled basketball performer, and that the low relationship between kinesthesis and basketball ability may have been due to the inadequacy of the kinesthesis tests.

A closely related study performed by Filer was reported by Stevens(76). Filer attempted to determine the differences between successful and unsuccessful musicians in terms of their kinesthetic judgment and the relationship between this judgment and success as a musician. Two groups, each containing twenty members, selected from 245 musicians were categorized as successful and unsuccessful. A battery of twelve tests designed to measure kinesthetic judgment was given to the groups. The investigator consistently found positive correlations between the successful musicians and their performance on each of the individual tests and on the battery as a whole. It was concluded that there was some degree of relationship between kinesthetic judgment and success as an instrumental musician.

The chief emphases in all of the above mentioned studies have been centered on the question of kinesthesis and individual accomplishment in motor performance. The first problem was to determine whether better performers have a keener kinesthetic sense than the poorer performers. More recent studies have dealt with the relationship between specific kinesthetic measures and specific skills. Many of the findings have not been statistically significant; however, along with each new piece of research comes a better understanding of kinesthesis and thus greater knowledge applicable to motor learning.

VI. MEASURES OF SKILL LEVEL

To objectively measure one's playing ability in a game necessitates determining the essential elements which make up the game. Once these elements have been found tests can be constructed which attempt to measure them. A number of tests and different methods of measuring ability in basketball, bowling and tennis have been developed. However, their reliabilities and validities vary considerably.

Basketball Skill Tests

Basketball skill tests have been constructed for both men and women. Since the rules of the men's and women's games differ, many of the skill elements are emphasized more in one game than in the other. For example, more value is placed upon dribbling in the men's game because the rules allow for an unlimited dribble. Consequently, the essential elements of the women's game do not correspond to those of the men's game. In the presentation of the review of literature, the author has mentioned various skill tests which were constructed to measure the basketball playing ability of girls and women.

One of the first battery of tests constructed was by Young and Moser. (63) They first determined the skill elements of basketball and then critically analyzed seventeen skill tests. On the basis of reliability, validity, objectivity, and practicality, five tests were selected for the battery. Included in the battery was a wall speed pass test, a moving target test, a bounce and shoot test, a free jump, and the Edgren ball handling test. The total test score had a coefficient of correlation of .859 when compared with the ratings of three expert judges, thus the battery had a high validity. Reliability was determined by correlating the scores received on the first administration of the battery with the scores on the second administration; however, this coefficient was not reported.

Schwartz(48) originally constructed a battery consisting of the following five tests: bounce over six foot area, jump and reach, pass and catch against wall, accuracy throw for goal, and pivot, bounce, and throw for goal. After an analysis of the data gathered from the administration of the battery the bounce over six foot area test was discarded because the range of scores was insufficient and the mean was too high. T-scores were constructed for the four remaining tests. The final basketball skill score was the mean of the four T-scores. The author did not give reliability or validity coefficients for the tests in her study.

Dyer, Schurig and Apgar(26) investigated and analyzed ten skill tests. From their findings six tests were eliminated. The four remaining tests all measured different aspects of motor ability; all contributed in due proportion to the total score, and all were regarded as reasonably valid measures of basketball motor ability of college women and secondary school girls. The battery consisted of a moving target test, bounce and shoot test, free jump and reach test, and the Edgren ball handling test. It was shown that the battery had a satisfactory degree of validity as correlations of judges' ratings with test scores gave validity coefficients ranging from .76 to .91. The reliability of the battery ranged from .89 to .90.

Scott and French(16) reported on two skill tests: the half-minute shooting test developed by Johnson, and a passing test which is a modification of the Edgren ball handling test. The shooting test measures the ability to hit the spot at which one is aiming, the ability to judge rebounds, and the ability to move quickly to get the ball and put it in play. The test is good for all players regardless of their positions. The reliability was reported as .70 when first and second trials were correlated. It was stepped up to .82 by the use of the Spearman-Brown Prophecy formula. Two hundred and thirty-three freshmen and sophomores in college served as subjects for the reliability figures. The validity was determined by correlating scores with a sports tests criterion for 155 college women. The validity was reported as .60. The passing test measures a combination of agility and ball handling. The reliability was .70 for the first and second trials and .82 when the Spearman-Brown correction was used for the sum of two trials. The same 233 freshman and sophomore college women served as subjects for this test. A validity of .51 was reported for the passing test when score were correlated with judges' ratings of ball handling ability of 154 freshman and sophomore women.

Leilich(71) analyzed statistically a number of basketball skill tests commonly used in physical education for college women in an attempt to determine the common components of the tests. In making this factor analysis of basketball skill, the twenty-eight measures used were subjectively evaluated in terms of their comparative validity, reliability, and administrative feasibility. The Thurston method of factor analysis was used in isolating the essential components contributing to test performance. The factors found basic to the tests were basketball motor ability, speed, ball handling involving pass accuracy and speed, and ball handling involving accuracy in goal shooting. Her findings resulted in the selection of the three test items which appeared to be the best measures of the more important skill elements of basketball. These three tests: bounce and shoot, half-minute shooting and push pass, were chosen on the basis of their validities as revealed by their correlation with the four factors found by Leilich. These correlations are shown in the table below:(42)

	Tests		
Factors	Bounce and Shoot	Push Pass	Half-minute Shoot
Motor Ability	.634	.378	.073
Speed	.211	.228	.475
Ball Handling Involving Speed and Accuracy	.307	.763	.360
Ball Handling Involving Goal Throwing	.176	.237	.598

The Professional Studies and Research Committee of the Midwest Association of College Teachers of Physical Education for Women constructed achievement scales for the three tests. The Miller[42] report provides a table of norms in the form of T-scores and percentile rankings for raw scores made by women physical education majors on the Leilich battery. Scores on which the norms were based were obtained from an adequate number of subjects in a nation wide sampling.

It is interesting to note that Leilich used Stevens' three item kinesthesis battery in making her factor analysis of basketball skills. The battery consisted of sidearm R 90^{o}, arm lift R 130^{o}, and arm pull 15 lbs. No significant correlations were found between any of the basketball or general motor ability variables included in this study and the kinesthetic factor as identified for this study. However, Leilich concluded that

> the lack of relationship . . . suggests the possibility that the kinesthesis tests used in this investigation fail to measure the phase of perception of movement necessary for successful performance in the tests designed to measure fundamentals of basketball motor ability. (71:43, 44)

<u>Bowling</u>

There have been no tests published to be used for measuring bowling ability. The actual bowling scores themselves appear to be a fairly adequate measure of relative bowling ability. Other items which have been used in determining general ability level include sum of the first ball in each frame of an entire game and scores made on four common spare set ups, bowling five balls at each set up.

Soladay(53) has recently done some statistical analysis of measures of bowling success. Her findings were based on the scores of 221 college women. Season averages appeared to be the most reliable measure of bowling success. The correlation of .910 between high series, the highest total of any three consecutive games bowled during the term, and season average is considered high. The correlation between high game, only, and season average was .844, and between season average of first balls and season average of games scores was .899. Under the conditions of the study it was concluded that high series, high game, and first ball scores may be used as measure of bowling success.

Tennis Skill Tests

Wagner[56] developed one of the first tests for measuring achievement in tennis skill for beginners. The five tests were for 1) forehand drive stationary, 2) backhand drive stationary, 3) forehand drive with footwork, 4) backhand drive with footwork, and 5) the serve. Helpers dropped the tennis balls in front of the testee for the stationary tests and threw the ball from the other side of the net for the drives requiring footwork. Neither the reliability or validity of these tests was determined.

Driver stated:

> There are four ways in which we may measure tennis ability: (1) the player's form by a subjective rating, (2) the player's playing ability by tournament results, (3) the player's rallying ability against a good opponent or backboard, (4) the player's ability to place the ball by sending the ball into certain areas on backboard or court.[4:160]

She emphasized that there is no proof that a player's form rating, or his rallying or placing ability correlate satisfactorily with his playing ability. However, she said that although tennis tests are invalid and unreliable they are still worthwhile. Driver has designed numerous tests for all skill levels. The tests are for the serve, forehand and backhand drives, and form and playing ability.

More recently, Broer and Miller[22][2] designed a test to measure the ability of college women to place forehand and backhand drives into the back-court area. The subject stands behind the baseline, bounces the ball to herself, and attempts to hit the ball into the back nine feet of the opposite court. Broer and Miller obtained a reliability coefficient for this test of .80 for both beginning and intermediate tennis players. The test's validity was determined by correlating the ratings given the subjects by various judges with the subjects' performance on the test. For the intermediate group, this correlation was .85, and for the beginner group it was .61.

Dyer[24][25][2] constructed a backboard volleying test of general tennis ability. Although the test does not analyze the various strokes and elements of the game, it has been very useful as a classification device for tennis and as a means of determining the progress being made in playing ability as a whole. The test consists merely of volleying a tennis ball as rapidly as possible against a backboard. A modification of the test placed a restraining line twenty-seven and a half feet from the backboard.[16] This test is administratively economical to conduct. The validity of the Dyer test has been determined by several methods. Dyer obtained a correlation of .92 between scores on this test and the relative positions of the subjects following round robin play. Fox[29] obtained a correlation of .53 between scores of college women beginning players on the Dyer test and subjective ratings of their ability to execute the forehand drive, backhand drive, and serve. Koski[2], using a twenty-eight foot restraining line, obtained correlations ranging from .51 to .68 between wall volley results and tournament play with college men as subjects. He also constructed norms for the beginning and intermediate ability levels.

Fox[29], using college women as subjects, compared the scores obtained on the Dyer test and the Broer-Miller test and reported a correlation of .69.

CHAPTER IV

PROCEDURE

The purpose of this study was to investigate kinesthesis in relation to skill level in basketball, bowling and tennis. A second purpose was to compare the differences of the three groups on their measures of kinesthetic sensitivity.

I. SELECTION OF KINESTHESIS BATTERY

In selecting the kinesthesis battery used for this study it was necessary to review all of the attempts at measuring kinesthesis that had previously been made. A review of the literature revealed specificity and diversity of the component factors of kinesthesis. Witte[79], Russell[75], and Wiebe[77] all employed the factor analysis technique to find the factors basic to the tests of kinesthesis. Witte identified seven factors, but did not devise a battery to measure them. Russell also factored out some distinguishable functions that are for the most part affected by kinesthetic sensitivity. Eight common factors emerged from Wiebe's multiple group method of factoring carried out on a battery of forty-four measures of kinesthesis. No battery was developed, however eight specific tests were suggested as the best reference tests. Earlier Wiebe[58] combined a number of tests to measure kinesthesis in college men;

however, there was no set battery and there were only thirty subjects used in his study.

Stevens[76] was one of the first to combine test items into a battery to establish a criterion measure of kinesthesis. Predictive indices of kinesthesis were then determined after multiple correlations and multiple regression equations were found. She suggested four different batteries containing six, five, four and three items. The multiple correlations ranged from .837 to .923, with the battery having the most items having the highest correlation.

Roloff[73] developed a battery of tests recommended as a measure of kinesthesis in college women. The preliminary testing involved computing reliabilities and validities on twelve tests selected from Young, Fisher, Scott and the Victory Through Fitness report. Several sets of five-item, four-item, and three-item batteries were devised through the use of the Doolittle Method of multiple correlation. The four-item battery containing balance stick, arm raising, weight shifting and arm circling was used for the Roloff study. It "was considered satisfactory and no five-item battery was found to be enough better to warrant the additional test item."[73:32] The regression equation used was: .75 balance stick - arm raising - weight shifting + 4.7 arm circling + 50. Its coefficient of multiple correlation was .88. The items in this battery were all mentioned as specific testing items used by Scott, Stevens, Wiebe, Witte and Russell. Two hundred college women were used as subjects for Roloff's investigation.

The four-item kinesthesis battery devised by Roloff was selected for use in this study on the basis of 1) the number of subjects from which data was gathered in developing the measures of kinesthesis, 2) the indication that this battery is a satisfactory measure of general kinesthetic sensitivity, 3) the availability of sufficient information concerning the nature of the battery, and 4) the feasibility of administration of the battery.

II. PRELIMINARY TESTING FOR RELIABILITY OF THE KINESTHESIS ITEMS

Prior to the testing of the specific subjects for this study it was necessary to administer the kinesthesis battery to determine the reliability of the test items. The nature of the testing was carefully explained to the graduate students who were asked to help with the administering of the testing program. They were given a chance to clarify the questions they had concerning the particular test they were to help with and were also provided the opportunity to test classmates in order to become more familiar with the testing procedure.

The subjects selected to be given the kinesthesis battery for reliability purposes were members of two volleyball classes taught by the author during the second semester of 1962-63. There were sixty-one subjects, all freshmen and sophomore women enrolled at the Woman's College of the University of North Carolina, who took part in the testing. They were asked not to reveal the nature of the tests they took as subjects who were to later take the test were not to practice the skills being tested. Subjects dressed in gymnasium costume and tennis shoes. The tests were administered in the Research Laboratory of Rosenthal Gymnasium during the students' scheduled physical education class periods.

The balance stick test was administered first. A complete explanation of this test and the other three tests which made up the kinesthesis battery as well as a diagram of the test organization can be found in the Appendix. For this test the subject was to place her foot lengthwise on a stick and then close her eyes and lift her other foot off the floor. The score was recorded as seconds balanced. One practice was given on the right foot and then three test trials, and then one practice on the left foot followed by three test trials. There were then three more trials on each foot. For purposes of determining the reliability, the total time on the first, third, fifth, eighth, tenth, and twelfth trials were correlated with the other six trials using the Pearson Product-Moment Correlation method and then stepped up by the Spearman-Brown Prophecy Formula. Half of the trials in each group were taken on the right foot and half on the left foot, and half of the trials were taken from the first six trials and half from the last six trials, thus the elements of practice and a dominant side were taken into consideration. The obtained coefficient was stepped up by the Spearman-Brown Prophecy Formula.

The weight shifting test consisted of shifting weight from one foot which rested on a solid block of wood to the other foot which was on a bathroom scale until half of the weight was on each foot. For the purpose of determining reliability, the test was administered twice shifting from the left foot and twice shifting from the right foot. For later testing, the weight shifting was done only once from each foot. The two trials from the right side were correlated with each other as were the trials from the left side. The reliability of the entire item was found by correlating the first trial on the right foot and the first trial on the left foot with the second trials on each foot. The Pearson Product-Moment Correlation method was used in treatment of the data.

For the arm raising test a goniometer was used to determine how far the subject had deviated in raising her arm to the horizontal. The test was given twice using the right arm and twice using the left arm. The reliability of the item was determined for both right arm and the left arm, as well as for the entire test as a whole, using the same procedure as above.

The arm circling test, in which the subject had to circle the arms in opposite directions at the same time, was done twice so the reliability could be determined. Here, again, the Pearson-Product Moment Correlation and Spearman-Brown Prophecy Formula were used. Between the first and second testing the subjects were given an opportunity to ask any question they had about the testing and the author further stressed the importance of not revealing the nature of the testing.

III. SELECTION OF SUBJECTS

The three groups of subjects used in this study were purposefully selected on the basis of their advanced skill level. There were twenty girls in each group: basketball, bowling and tennis, and thus a total of sixty subjects. All of the subjects were enrolled at the Woman's College of the University of

North Carolina during the 1962-63 academic year.

Basketball

The basketball players were selected from the Woman's College's extramural team and from the physical education majors' tournament held in December, 1962 and January, 1963. Used in this study were twelve varsity players plus eight additional players subjectively rated as the highest skilled in the majors' tournament. All but two subjects were physical education majors. Five seniors, six juniors, eight sophomores and one freshman made up the group.

All of the basketball players were contacted individually and asked to participate in the study at which time the purpose and nature of the testing were explained, and, also, a time for taking the kinesthesis battery was arranged. The varsity players were contacted as a group to determine the best time to take the Leilich battery of basketball tests. The eight other subjects were contacted individually and scheduled for the basketball skill testing.

Bowling

The bowlers for this study were selected from the one hundred and sixty sophomore women who took bowling during the first semester of the 1962-63 academic year. Skill level was assessed on the basis of the average of the last ten lines bowled in class. There were twenty-two who attained an average of 115 or above and who were enrolled at the Woman's College during the second semester. These women were sent a letter asking them to participate in the study. A copy of this letter may be found in the Appendix. The purpose of the testing was explained when the bowlers called to say they would participate in the study. At this time individual times were arranged for the kinesthesis testing. Those who did not answer the letter were contacted by the author at which time the preceding was explained. There was a total of twenty bowlers who participated in the study.

Tennis

The tennis players were selected from one hundred and three students enrolled in five intermediate tennis classes. Two of the classes were taught the first semester and three the second semester of the 1962-63 academic year. Twenty-one students who were registered for tennis the first semester and who scored above thirty-two on the Dyer Wallboard test were sent letters asking them to participate in the study. A copy of the letter may be found in the Appendix. Twelve students replied to the letter and agreed to take part. When they called to say they would participate, the purpose of the testing was explained and individual times for taking the kinesthesis battery and the Dyer Wallboard test were arranged. Eight additional tennis players, who were taking intermediate tennis in the second semester, were selected on the basis of the initial score they made on the Dyer Wallboard test administered during February, 1963. Those scoring above thirty were individually contacted and asked to participate in the study. The entire tennis group was composed of six freshmen and fourteen sophomores.

IV. SELECTION OF SKILL TESTS

Basketball

A review of the existing basketball skill tests for girls and women revealed several batteries as well as a number of individual tests that have been devised. Leilich[71] analyzed statistically twenty-eight basketball skill test items commonly used in physical education for college women in an attempt to determine the common components of the tests. The factors found basic for the tests were basketball motor ability, speed, ball handling involving pass accuracy and speed, and ball handling involving accuracy in goal shooting. Her findings resulted in the selection of the three test items which appeared to be the best measures of the more important skill elements of basketball. These three tests: bounce and shoot, half-minute shooting and push-pass, were chosen on the basis of their validities as revealed by their correlation with the four factors found by Leilich. This same battery of tests was selected for use in the study. A complete description of the test items may be found in the Appendix.

Bounce and Shoot. Two eighteen foot dotted lines were drawn on the floor at either side of the basket. They extended from the midpoint of the endline and at forty-five degree angles from the endline. A twenty-four inch solid line was centered at the end of the dotted line and perpendicular to it. Starting from a point one foot behind and thirty inches to the outside of the end of the eighteen foot line additional eighteen inch lines were drawn. These were parallel to the twenty-four inch line. The front legs of a chair were placed on each eighteen inch line and a ball was placed on each chair. A diagram of the markings for this and the other basketball tests may be found in the Appendix. A ball catcher stood behind each chair and replaced the ball on the chair after each pass.

The subject started at the twenty-four inch line at the right side of the basket. On signal from the timer, the subject picked up the ball from the chair, bounced it once, shot, recovered the rebound and passed the ball back to the catcher on the right side. She then ran to the left side, picked up the ball and repeated the sequence. The procedure was repeated five times on each side, making a total of ten shots. There was both a time and an accuracy score. The time score was the nearest tenth of a second from the signal "ready, go" until the ball was caught after the tenth shot. The addition of one second was added to the time score for each foul. The fouls were: running with the ball, double bounce, and failure to start from behind the twenty-four inch line. The accuracy score for shooting was scored on the following basis: two points for baskets made and one point for hitting the rim but missing the basket. This test was administered twice. The trial with the best score combining time and accuracy was used in determining the battery score.

<u>Half-Minute Shooting</u>. The subject stood at any position she selected on

the court, with the ball in her hands. At the signal "ready, go" she shot as many baskets as possible in thirty seconds. Her score was the number of baskets made in the time limit. If the ball had left her hands when the thirty seconds ran out, the basket counted if made. This test was administered twice. The score on this test item was the largest number of baskets made in two trials.

Push Pass. A target was made on the wall using one-half inch black tape for the markings. The target consisted of three concentric circles, with the lower edge of the outer circle twenty-four inches from the floor. The circles had radii of ten, twenty, and thirty inches, respectively. The subject stood behind a restraining line ten feet from the wall and passed the ball, using a two-hand chest pass, as many times as possible in a thirty second period. The score represented the total number of points made with five, three and one points awarded for hitting within the inner, middle and outer circles, respectively. A ball hitting a line scored the higher value. It was a foul if the subject stepped on or over the ten foot line or if a pass other than a two-hand chest pass was used. No points were scored when a foul occurred. This test was administered twice. The trial with the largest number of points scored was used in figuring the battery score.

Bowling

Soloday[53] found that season averages, based on the bowling scores of

221 college women, appear to be the most reliable measure of bowling success. This finding, along with the dearth of bowling skill tests, led the author to use the average of the last ten lines the subjects bowled during their semester of bowling class as their measure of bowling skill. This score was the same score which was used in selection of the subjects.

Tennis

In reviewing the literature concerning tennis skill tests it was found that the earlier tests developed by Wagner[56] and by Driver[4] were invalid and unreliable. The more recent forehand and backhand drive test devised by Broer and Miller[22] and a backboard volleying test devised by Dyer[25] have been found to be fairly reliable and valid. The Broer-Miller test measures the ability of college women to place forehand and backhand drives into the back-court area while Dyer's test is a measure of general tennis ability. A modification of the Dyer test which included a restraining line was selected for use in this study for the following reasons: it had been given to all students enrolled in intermediate tennis classes; it purports to measure general skill in tennis, rather than a specific skill; and the test is administratively economical to conduct. The test consists merely of volleying a tennis ball as rapidly as possible against a backboard. There is a restraining line twenty-seven and a half feet from the backboard. The ball may bounce any number of times before it is hit just as long as it is hit from in back of the restraining line. The final score is the total number of volleys executed in three thirty second testings.[16] A complete explanation of the test may be found in the Appendix.

V. ADMINISTRATION OF TESTS

Sixty subjects, purposefully selected on the basis of their level of skill, took part in the testing for this study. The kinesthesis battery, Leilich battery, and Dyer wallboard test were all administered during the first two weeks of March, 1963.

Kinesthesis

Three test administrations were necessary to complete the kinesthesis testing of all sixty subjects. The testing took place in the Research Laboratory of Rosenthal Gymnasium. Graduate students, who were used during the reliability testing of this battery, again acted as judges, timers and assistants. The subjects progressed from the balance stick test, which had a total of twelve trials, to the weight-shifting station. Weight-shifting was performed from each side once. Arm raising was next. The degrees of variation from the horizontal were measured twice raising the right arm and twice raising the left arm. At the last station arm circling was performed once. Each of the tests using the arms was done in a closed room so that subjects who had yet to take those tests were not aware of what was expected of them. A diagram of the test organization and a sample of the scorecard may be found in the Appendix.

Basketball

The twenty basketball subjects were given the Leilich battery at one of two testing times. Each subject was given her kinesthesis scorecard on the back of which all of the basketball data was recorded. A copy of the basketball scorecard appears in the Appendix.

There were three testing stations used during a single administration of the battery. A diagram of the testing organization appears in the Appendix. Each subject took a test item twice, resting between trials, and then rotated on to the next station. Graduate students acted as scorers, timers and judges. The test administrators were given typed instructions explaining the administration of the test items and also directions which were to be read to the subjects. When help was needed, subjects acted as scorers for the half-minute shooting and as ball catchers for the bounce and shoot test.

Tennis

A modification of the Dyer wallboard test was given to the twenty tennis players at their convenience during the first two weeks in March. The time for this testing was arranged when the subject agreed to participate in the study. Most of the subjects were given the test before or after their regularly scheduled physical education class; however, several of the subjects took this test following the kinesthesis battery. The author did all of the administering of the tennis test. The final score which each of the subjects received was placed in the upper right hand corner of the kinesthesis scorecard. The directions for administration of this test may be found in the Appendix.

VI. TREATMENT OF DATA

In treating the data for this study, the first step was to determine the reliability of the items in the kinesthesis battery. The Pearson Product-Moment method of correlation was used to determine the reliability of the following items: balance stick, weight shifting right, weight shifting left, combined weight shifting, arm raising right, arm raising left, combined arm raising, and arm circling. The obtained coefficients were stepped up by the Spearman-Brown prophecy Formula.

The ranges, means, and standard deviations were determined for the scores on the kinesthesis battery made by each of the three groups of subjects: basketball, bowling and tennis. Fisher's "t" was applied to determine if there were a significant difference between means of the three groups. A "t" value of 2.025 was required for .05 level of significance, and a "t" value of 2.713 for .01 level of significance.

The mean scores on the kinesthesis battery for the three groups of subjects, as a whole, and the subjects chosen for reliability purposes were tested for significance of differences by using the "t" for large uncorrelated groups. The "t" values required for .05 and .01 levels of significance were 1.671 and 2.390, respectively.

The significance of difference of performance on the dominant and nondominant sides for all subjects on the balance stick, weight shifting, and arm raising items on the kinesthesis battery were determined by the use of the "t" test for large correlated groups. The "t" values required for .05 and .01 levels of significance were 1.671 and 2.390, respectively.

In determining the relationship between kinesthesis and skill level in basketball, bowling and tennis the Pearson Product-Moment method of correlation was used.

CHAPTER V

ANALYSIS OF DATA

The purpose of this study was to investigate kinesthesis in relation to skill level in basketball, bowling and tennis. A second purpose was to compare the scores made by three purposefully selected groups of subjects on a kinesthesis battery. The subjects used in this study were chosen on the basis of their skill level. There were twenty girls in each group: basketball, bowling and tennis. All of the subjects were enrolled at the Woman's College of the University of North Carolina during the 1962-63 academic year.

I. PRESENTATION OF DATA

The first problem inherent in this study was to determine the reliability of the items in the kinesthesis battery which was chosen for use. Sixty-one students registered in two volleyball classes at the Woman's College of the University of North Carolina during the second semester of the above school year served as subjects for reliability purposes. The four items tested for reliability, using the Pearson Product-Moment method of correlation, were balance stick, weight shifting, arm raising and arm circling.

In determining the reliability of the balance stick test, the total time on the first, third, fifth, eighth, tenth and twelfth trials were correlated with the other six trials. By combining the trials in this manner, the elements of practice and a dominant side were taken into consideration as half of the trials in each group were taken on the right foot and half on the left foot, and half from the first six trials and half from the last six trials.

The weight shifting test was administered twice in order for the reliability of the test item to be determined. Three different reliability figures were found: right foot, left foot and both feet combined. The two trials shifting from the right foot were correlated as were the two trials from the left foot. Combined weight shifting was determined by correlating the first trials on each side with the second trials. The Pearson Product-Moment Correlation method was used in treatment of the data. The same procedure was used in determining the reliability of the arm raising item; however, the Roloff battery called for this test to be administered twice on each side. The arm circling item was administered twice in order for the reliability of the item to be determined.

Table I shows the reliability coefficients and the coefficients that were obtained when stepped up by the Spearman-Brown Prophecy Formula. These latter coefficients were figured for the items which were administered only the number of times which Roloff specified in her battery. The reliabilities ranged from .5089 to .8375. All of the reliability coefficients were submitted to a table of r's and found significant at above the .01 level.

In comparing the kinesthetic score of the three groups of subjects selected for their skill in basketball, bowling and tennis, the ranges, means and standard deviations were first determined. An extreme score of 143.375,

TABLE I

RELIABILITIES OF KINESTHESIS TEST ITEMS

N = 61

	r	r*
Balance Stick	.6856	.8135
Right Weight Shifting	.5089	
Left Weight Shifting	.6728	
Both Weight Shifting	.7804	
Right Arm Raising	.5684	.7248
Left Arm Raising	.6795	.8092
Both Arm Raising	.7205	.8375
Arm Circling	.7722	

*Estimated by Spearman-Brown Prophecy Formula which was 30.775 points above the next highest score in the tennis group, greatly affected both the mean and the standard deviation for that group. These figures are found in Table II, page 67.

Fisher's "t" was applied to determine if there were a significant difference between means of the three groups. No "t's" were found to be significant at better than the .05 level. The greatest difference existed between the bowling and the tennis group. The obtained "t's" calculated from the data appear in Table III, page 68.

The mean scores on the kinesthesis battery for the three groups of subjects, as a whole, and the subjects chosen for reliability purposes were tested for significance of differences by using the "t" test for large uncorrelated groups. The obtained "t" value, as well as the ranges, means and standard deviations for these two groups appear in Table IV, page 69. The "t" value required for .01 level of significance was 2.618 and the obtained "t" was 4.5733. Thus there was a true difference between the two groups' scores on the kinesthesis battery at better than the .001 level of significance with the subjects purposefully selected on the basis of their skill scoring higher.

Tests of significance were performed to see if there were significant differences in the scores made on the dominant and nondominant sides on the balance stick, weight shifting and arm raising kinesthesis items. The scores made by the basketball, bowling and tennis subjects were subjected to the "t" test for large correlated groups. The subjects scored better on the weight shifting and arm raising items on the nondominant side and better on the

TABLE II

RANGES, MEANS AND STANDARD DEVIATIONS FOR THE THREE GROUPS OF SUBJECTS ON THE KINESTHESIS BATTERY

Skill	N	Ranges	Means	S. D.
Basketball	20	37.55 - 121.3	82.25	23.3088
Bowling	20	33.85 - 116.525	78.75	25.0313
Tennis	20	49.55 - 143.375	84.7	24.1878

TABLE III

THE SIGNIFICANCE OF DIFFERENCE BETWEEN MEAN SCORES ON THE KINESTHESIS BATTERY FOR THE THREE GROUPS OF SUBJECTS

	t*
Basketball - Bowling	.4460
Basketball - Tennis	.3179
Bowling - Tennis	.7451

*df = 38; t = 2.025 at .05 level of significance

TABLE IV

THE SIGNIFICANCE OF DIFFERENCE BETWEEN MEAN SCORES ON THE KINESTHESIS BATTERY FOR THE THREE GROUPS OF SUBJECTS AND THE SUBJECTS CHOSEN FOR RELIABILITY PURPOSES

Subjects	N	Range	Mean	S. D.	t*
Basketball, Bowling and Tennis	60	33.85 - 143.375	81.9	24.3089	
					4.5733
Reliability (volleyball classes)	61	-8.45 - 124.9	60.409	27.4955	

*df = 119; t = 3.374 at .001 level of significance

dominant side for the balance stick test. However, none of the obtained "t's" met the required value for .05 level of significance. These data appear in Table V, page 71.

In determining the relationship between kinesthesis and skill level in basketball, bowling and tennis the Pearson Product-Moment method of correlation was used. All of the obtained coefficients, as shown in Table VI, page 72, were neglible.

II. INTERPRETATIONS OF DATA

A four item kinesthesis battery was administered to students in two volleyball classes for the purpose of determining the reliability of the items. Reliability of the four items expressed a degree of relationship high enough to indicate satisfactory consistency throughout the testing. The coefficient of multiple correlation for the battery was .88, as Roloff determined by the Doolittle method.

The data gathered from scores on the kinesthesis battery for the three groups of subjects purposefully selected on the basis of their skill level in basketball, bowling and tennis were quite similar. The tennis group had the largest range of scores as well as the highest score. The extreme score which one of the tennis players received resulted from a high score on only the balance stick item in the battery. Disregarding this one subject's score, the tennis group would have had the smallest range of scores, however the mean score for the group would have been just below that of the basketball group.

TABLE V

THE SIGNIFICANCE OF DIFFERENCE BETWEEN SCORES ON THE DOMINANT AND NONDOMINANT SIDES FOR THE BALANCE STICK, WEIGHT SHIFTING AND ARM RAISING ITEMS ON THE KINESTHESIS BATTERY FOR THE THREE GROUPS OF SUBJECTS

Item	t*
Balance Stick	1.5102
Weight Shifting	1.6138
Arm Raising	.9473

*df = 59; t = 1.672 at .05 level of significance

TABLE VI

CORRELATION COEFFICIENTS BETWEEN SKILL LEVEL AND KINESTHETIC SENSITIVITY

Skill	N	r
Basketball	20	.0987
Bowling	20	-.0828
Tennis	20	.1166

It is highly possible that scores on a different kinesthesis battery would have varied considerably. Attempts at measurement of kinesthesis have brought forth the following conclusions: kinesthesis tests in general show little inter-relationship, which would lead one to assume considerable specificity of function, and the sensation of kinesthesis is made up of many elements or forms of response, thus there is little evidence that it might be a general capacity.[49]

It is believed that kinesthesis is specific to the part of the body being tested and the nature of the test. The author felt that the four items in Roloff's kinesthesis battery: balance stick, weight shifting, arm raising and arm circling, all contained movement patterns which were called upon in the execution of basketball, bowling and tennis skills, as balance, body control, precision in arm movements and coordination play an important part in these three activities.

Stevens[76] recommended that a comparison be made of kinesthetic discrimination of two groups selected for motor ability from the general population rather than from physical education majors. In this study, two groups did not have any physical education majors. One of these groups was selected on the basis of skill level shown in bowling classes and the other group selected for skill level in intermediate tennis classes. The third group, selected for its basketball ability, had only two subjects who were not physical education majors, the other eighteen subjects were majors. There was not a significant difference between mean scores on the kinesthesis battery for any combination of two groups of the three groups of subjects. The greatest difference existed between the bowling and tennis groups where the obtained "t" was .7451. A "t" of 1.729 was required for .05 level of significance. The one extreme score in the tennis group had a marked effect on this difference in mean score.

A highly significant difference was found between mean scores on the kinesthesis battery for the three groups of subjects: basketball, bowling and tennis, and the subjects chosen for reliability purposes. The number of subjects in these two larger groups were similar, however the ranges of kinesthesis scores differed considerably. These data, which appear in Table IV, exemplify the relationship of kinesthesis with motor ability which most definitions of kinesthesis suggest. It is believed that kinesthesis aids in gaining skill, for a person who can perceive his own motor patterns and positions, and has developed the ability to participate emphatically when others are "doing," can learn more quickly and recognize motor problems readily.[16]

No attempt was made to evaluate the amount of motor training which the subjects involved in this study had previously had, nor was any measure of skill taken for the reliability subjects. However, the subjects in the volleyball classes demonstrated a wide range of skill level in a variety of activities. As a group, their skill level would be considered much lower than the sixty subjects selected on the basis of their skill level in basketball, bowling and tennis. The relationship found between these two larger groups is congruent with Stevens'[76] findings that individuals who were more trained in motor movements or who had more motor experience showed a more highly developed kinesthetic sense than did those who were untrained.

Studies previous to this one have not made mention of the varying of scores on kinesthesis items which were performed on both sides of the body. In this study tests of significance were carried out to see if there were significant differences in the score made on the dominant and nondominant sides on the balance stick, weight shifting and arm raising kinesthesis items. The scores made by the basketball, bowling and tennis subjects, which included three left-handers were subjected to the "t" test for large correlated groups. Although none of the differences were significant, the subjects did perform better on their nondominant side on both the weight shifting and arm raising items, and better on their dominant side on the balance stick test. A possible reason why the subjects shifting weight did better when going on to their nondominant side may be due to the fact that the weight was first on the dominant side and then shifted to the nondominant side, and thus the feeling in the dominant side controlled the degree of shifting.

The correlations that were found in determining the relationship between kinesthesis and skill level in basketball, bowling and tennis were all neglible. It is likely that in this study, where only twenty subjects were used in each group, the degree of advanced skill level and superior kinesthetic acuity did not differ significantly in order to show a relationship between the two items. These subjects had a kinesthesis sense level significantly above the average students. It is quite likely that factors such as motor experience and motor training may have been the items differentiating these subjects as far as their superior skill level. The neglible relationship found between skill level and kinesthesis may also have been due to the inadequacy of the kinesthesis battery selected. It should be emphasized that all findings in attempts to measure kinesthesis point toward specificity and diversity of the component factors of kinesthesis. The components of kinesthesis which are necessary for developing advanced skill in basketball, bowling and tennis may not have been measured in the Roloff battery.

The relationship found between kinesthesis and skill level in basketball is not consistent with Zimmerman's[80] study of two years ago. She investigated kinesthesis in relation to high and low levels in basketball ability and reported that a low but significant relationship existed between the total kinesthesis score and the level of basketball performance. The kinesthesis score she used was computed from T-scores on twelve test items, and the basketball score was computed from three skill tests, two of which were similar to items in the Leilich battery. The difference in findings may be due to the nature of the measures used in the testing.

The nature of this study was different from previous studies in the area of kinesthesis as the subjects were purposefully selected on the basis of skill level, with three different activities being represented. College women who possessed a high level of skill in either basketball, bowling or tennis were used as subjects. The relationships found between kinesthesis and skill level were all neglible. Results of comparing the kinesthetic sensitivity of skilled performers with "nonskilled" performers who were tested for reliability purposes showed a significant difference between the two groups. These findings were similar to those of Fisher[68] and Stevens[76]. The investigation into kinesthetic items done on the dominant and nondominant sides of the body was a new type of inquiry about the kinesthetic sense.

This study has produced findings which add to the knowledge of the kinesthetic sense and also which may help to make our understanding of the nature of the "muscle sense" more clear.

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was undertaken for the purpose of determining if a relationship existed between kinesthesis and the level of skill of three groups of subjects selected on the basis of their ability in basketball, bowling and tennis, and to compare the differences of the three groups of subjects on their measures of kinesthetic sensitivity. All of the subjects were enrolled at the Woman's College of the University of North Carolina during the 1962-63 academic year.

A kinesthesis battery designed by Roloff(73) was used as the measure of kinesthetic sensitivity. This battery included four items: balance stick, weight shifting, arm raising and arm circling. Members of two volleyball classes taught by the author were given the battery to determine the reliability of the items. All of the reliability coefficients ranged between .5089 and .8375, and were found to be above the .01 level of significance.

The subjects selected for use in this study were given a skill test in their activity to attain a reliable measure of their performance at the time of the kinesthesis testing. The basketball players were administered the Leilich battery, the tennis players were administered a modification of the Dyer wallboard test, and the average of the last ten lines the bowlers had bowled in class during the first semester was used as a measure of their bowling skill.

There were twenty girls in each group. The kinesthesis battery was administered to all sixty of these subjects.

Graduate students assisted with the administration of the tests which were given during the first two weeks of March, 1963. The ranges, means and standard deviations were determined for the scores on the kinesthesis battery made by each of the three groups of subjects. Fisher's "t" was applied to determine if there were any differences between the means of the three groups.

The mean scores on the kinesthesis battery for the three groups of subjects, as a whole, and the subjects chosen for reliability purposes were submitted to a "t" test of significance. This same statistical procedure was used to determine if there were a significant difference in performance on the dominant and nondominant sides for the purposely selected subjects on the balance stick, weight shifting and arm raising items.

In determining the relationship between kinesthesis and skill level in basketball, bowling and tennis, the Pearson Product-Moment method of correlation was used.

FINDINGS

These findings resulted from the treatment of the data in this study:

1. The reliability of the four items on the kinesthesis battery ranged from .5089 to .8375. Considering each item as a whole, the reliability coefficients were: balance stick .8135, weight shifting .7804, arm raising .8375 and arm circling .7722.
2. The tennis group had the highest mean score and the largest range on the kinesthesis battery. Its range, mean, and standard deviation were:

49.55 to 143.375, 84.7 and 24.1878, respectively.

3. The range, mean and standard deviation for the basketball group on the kinesthesis battery were: 37.55 to 121.3, 82.25 and 23.3088, respectively.

4. The range, mean and standard deviation for the bowling group on the kinesthesis battery were: 33.85 to 116.525, 78.75 and 25.0313, respectively.

5. No group scored significantly higher on the kinesthesis battery.

6. The mean score on the kinesthesis battery for the three groups of subjects as a whole was higher than the mean score for the subjects chosen for reliability purposes. This difference was above the .01 level of significance.

7. The three groups of subjects scored better on the weight shifting and arm raising items on their nondominant side and better on their dominant side for the balance stick test; however, none of the differences in performance were statistically significant.

8. The correlation coefficients between skill level and kinesthetic sensitivity were all neglible. The obtained r's for kinesthesis and basketball, bowling and tennis were .0987, -.0828, and .1166, respectively.

CONCLUSIONS

In drawing conclusions, it is necessary to recognize that they can be made only within the limitations of this study. The following conclusions seem justifiable on the basis of the above mentioned findings:

1. Each of the four items in the kinesthesis battery was a reliable measure as administered in this study.

2. There was no significant difference between mean scores on the kinesthesis battery for the three groups: basketball, bowling and tennis.

3. The three groups of subjects selected on the basis of their skill ob-

tained a higher mean score than the reliability subjects on the kinesthesis battery. This difference was statistically significant above the .001 level of significance.

4. According to this study, there was no relationship between kinesthesis and skill level in basketball, bowling or tennis.

CHAPTER VII

CRITIQUE AND SUGGESTIONS

Our inadequate understanding of the nature of kinesthesis has greatly affected the attempts at its measurement. Until we find out more about the kinesthetic sense we cannot make confident conclusions and implications from studies in this area. This study was limited by the availability of a statistically proven reliable and valid test of kinesthesis as well as by the number of subjects used in the three groups. Within these limitations, a more accurate study might have resulted if motor training and motor experience were taken into consideration when measuring skill level. It is recommended that subjects chosen for use in a similar study be selected from a larger cross-section of the population and that the number of subjects in each group be increased.

The author would like to suggest that more studies be undertaken in this area. Ensign(67), Ragsdale(12) and Phillips and Summers(45) all stress the importance of kinesthesis in the early stages of learning. Several suggestions for future investigations are:

1. to construct a battery or batteries of tests to measure kinesthesis in youngsters.
2. to find the relationship between kinesthesis and general motor ability in youngsters of five to seven years of age.
3. to conduct a longitudional study to determine the relationship between kinesthesis and general motor ability for the same subjects

over a period of fifteen years, thus a record of motor training and motor experience could be accurately taken into account, and a better picture of the role of kinesthesis in motor learning may result.

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APPENDIX

COPY OF LETTER TO BOWLERS

Department of Physical Education
The Woman's College
February 25, 1963

Dear

You are one of the twenty-five students out of 160 who had a bowling average above 115 for last semester. On the basis of the advanced bowling ability you demonstrated in bowling class, you have been selected to take part in a short battery of tests. It will require approximately thirty minutes of your time to come to Rosenthal gymnasium, participate in the testing, and return to your dorm. Gymsuits and tennis shoes are to be worn for the testing. The testing will be held Tuesday, March 5th 7-8p.m., Friday, March 8th 3-4p.m., and Saturday, March 9th 2-3p.m.

Your participation will facilitate a more accurate measure as only advanced level bowlers are needed. I would appreciate it if you could call me at ext. 283 between 6:30 and 10:30 on Feb. 28th or March 1st to let me know whether or not you will be willing to participate. At this time I can arrange the exact testing time which best fits your schedule. Thank you for your attention to this matter.

Sincerely,

Becky Sisley

COPY OF LETTER TO TENNIS PLAYERS

Department of Physical Education
Woman's College
February 25, 1963

Dear

On the basis of the high score you made on the Dyer wallboard tennis skill test last semester you have been selected to take part in a short battery of tests. It will require approximately thirty minutes of your time to come to Rosenthal gymnasium, participate in the testing, and return to your dorm. The testing will be held Tuesday, March 5th 7-8p.m., Friday, March 8th 3-4p.m., and Saturday, March 9th 2-3p.m. Gymsuits and tennis shoes are to be worn for the testing.

Your participation will facilitate a more accurate measure as only the highest skilled tennis players are needed. I would appreciate it if you could call me at ext. 283 between 6:30 and 10:30 on Feb. 28th or March 1st to let me know whether or not you will be willing to participate. At this time I can arrange the exact testing time which best fits your schedule. Thank you for your attention to this matter.

Sincerely,

Becky Sisley

DESCRIPTION OF KINESTHESIS TESTS[47]

Balance Stick

A stick which is one inch square and twelve inches long is securely taped to the floor with adhesive tape. The subject is given the following verbal instructions:

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

One demonstration is given while giving instructions. The subject is timed from the moment she lifts her foot until she opens her eyes or touches the floor. There are 12 trials which make up the total score: 3 right, 3 left, 3 right, and 3 left. The total score is recorded in seconds.

Weight Shifting

The equipment for this test consists of a bathroom scale and a block of wood one foot long and half a foot wide. The thickness of the block is that which will make the block the same height as that of the scale platform. The block is placed next to the scale so that they are side by side, with the block on the left side. The subject places her left foot on the block and the right foot on the scale. One demonstration is made while the following verbal instructions are given:

> Stand on the scale so I can determine your weight. Then put your left foot on this block and place just enough weight on your right foot to run the scale up to ______ pounds. You may have two practices to run the scale up to ______ pounds and then you will be asked to start with the scale at zero, look away and try to run the scale up to the same weight. As you see, it is hard to hold the scale steadily so you will have to say "now" when you think you have the scale where you want it.

The subject is told to place one-half of her weight on the scale, but is not told that the required weight is one-half of her weight. The test is repeated on the other side with the left foot on the scale. The score on the test is the sum of the deviations of the right foot and and left foot from the required weight, one-half of the subject's weight. The score is given in pounds. A perfect score is zero.

Arm Raising

> The subject is given the following verbal instruction:
>
> Raise your right arm out sideward to a horizontal position with the palm facing down.

The instructor faces the subject and uses a goniometer to determine how far the subject has deviated in raising her arm to the horizontal. A line from the shoulder joint to the base of the thumb should be parallel to the floor. The deviation is recorded as degrees of deviation from the horizontal. The arm is lowered and the test is repeated. Then the test is given twice using the left arm. The total score is the sum of deviations on the four trials and is recorded in degrees. A score of zero is a perfect score.

Arm Circling

The instructor gives one demonstration of this test while the following verbal instructions are given:

> Try to circle your arms in complete circles but in opposite directions so that one arm makes a complete circle going forward while the other arm makes a complete circle going backward. It will look like this.

The subject is not allowed to do the exercise with the instructor. The instructor rates the subject on her performance using the following 9-point scale in which each attempt to do the exercise is considered as a trial:

9 - Performed in good form on first attempt.
8 - Performed in good form on second attempt.
7 - Performed in fair form on second attempt.
6 - Performed in fair form on third attempt.
A second demonstration is given if the subject has not performed the exercise after three attempts.
5 - Performed in good form on fourth attempt.
4 - Performed in fair form on fifth attempt.
3 - Performed in poor form on sixth attempt.
2 - Performed in poor form on seventh attempt.
1 - Subject unable to perform exercise in seven attempts.

KINESTHESIS SCORECARD

NAME GROUP

Balance Stick 1. _____ 4. _____ 7. _____ 10. _____ Total _____

2. _____ 5. _____ 8. _____ 11. _____ X .75

3. _____ 6. _____ 9. _____ 12. _____ Score _____ (A)

Weight Shifting R ______ L ______ Score _____ (B)

weight _____

Arm Raising R ______ L ______

R ______ L ______ Score _____ (C)

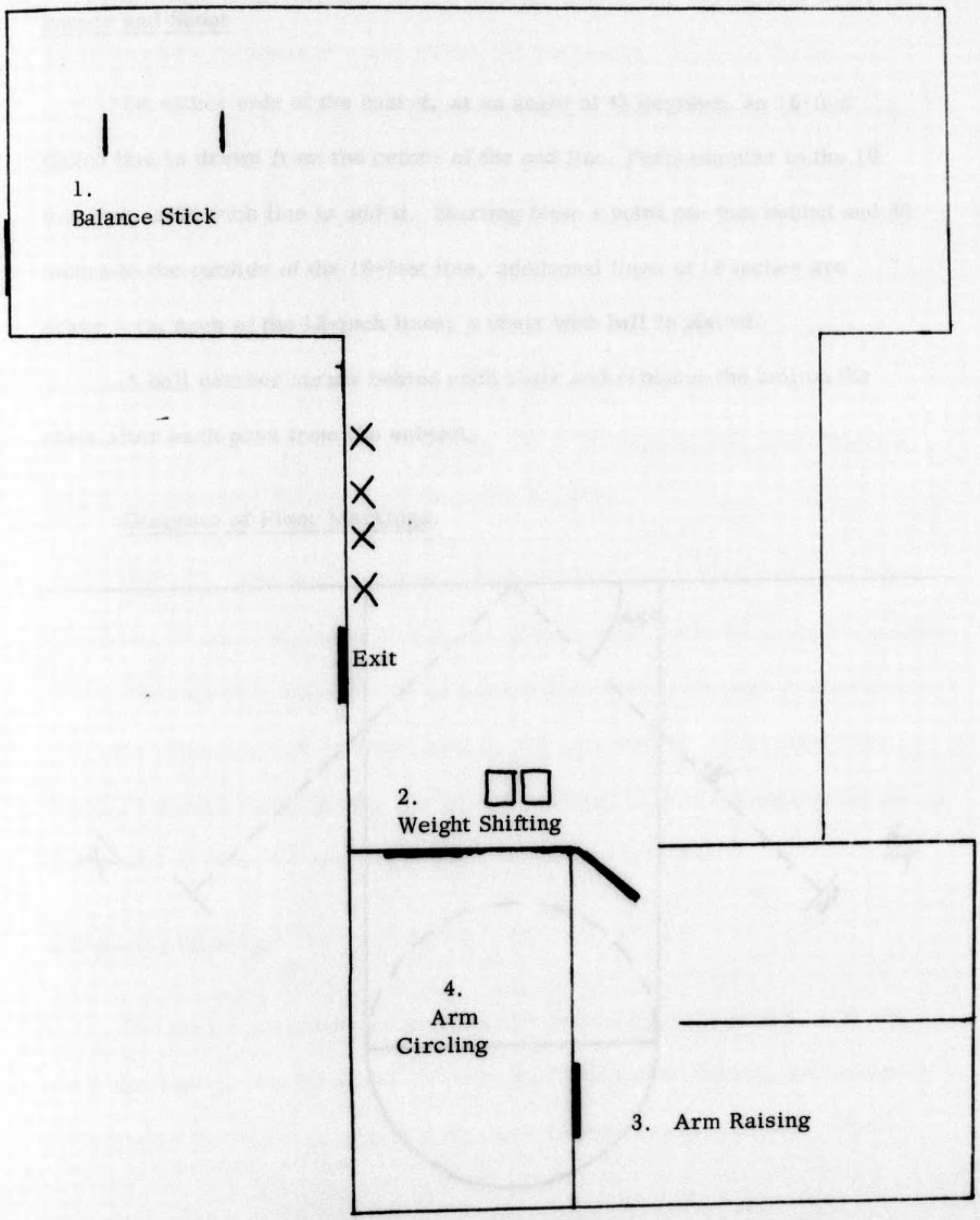
Arm Circling ______ _____

X 4.7

Score _____ (D)

Final Score = (A) ______ - (B) ______ - (C) ______ + (D) ______ + 50 = ______

DIAGRAM OF TEST ORGANIZATION FOR KINESTHESIS BATTERY



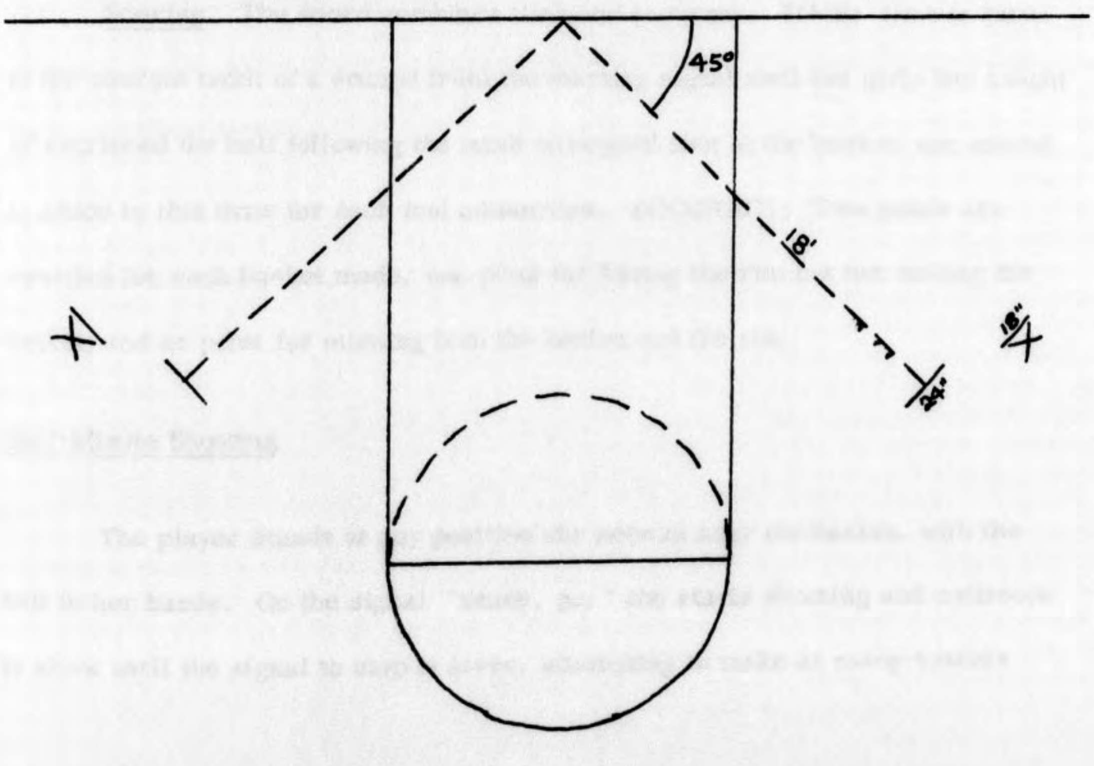
DESCRIPTION OF LEILICH BATTERY (2) (9)

Bounce and Shoot

On either side of the basket, at an angle of 45 degrees, an 18-foot dotted line is drawn from the center of the end line. Perpendicular to the 18-foot line, a 24-inch line is added. Starting from a point one foot behind and 30 inches to the outside of the 18-foot line, additional lines of 18 inches are drawn. On each of the 18-inch lines, a chair with ball is placed.

A ball catcher stands behind each chair and replaces the ball on the chair after each pass from the subject.

Diagram of Floor Markings.



Instructions. In taking the test, the subject starts behind the 24-inch line at the right of the basket. At the signal, "ready, go," she picks up the ball from the chair, bounces it once, shoots for the basket, recovers the rebound, and passes the ball to the catcher behind the chair from which she got the ball. She then runs to the chair on the left side and repeats as before. This performance is continued, alternating five times on each side. Each bounce must start from behind a 24-inch line. Fouls consist of running with the ball, double bouncing, and failure to start time in back of the 24-inch line. The test terminates when the subject has retrieved the ball after the tenth shot at the basket. The test is administered twice. The trial with the best total score is used in determining the score on the entire battery.

Scoring. The score combines time and accuracy. TIME: time is taken to the nearest tenth of a second from the starting signal until the girl has caught or retrieved the ball following the tenth attempted shot at the basket; one second is added to this time for each foul committed. ACCURACY: Two points are awarded for each basket made, one point for hitting the rim but not making the basket, and no point for missing both the basket and the rim.

Half-Minute Shooting

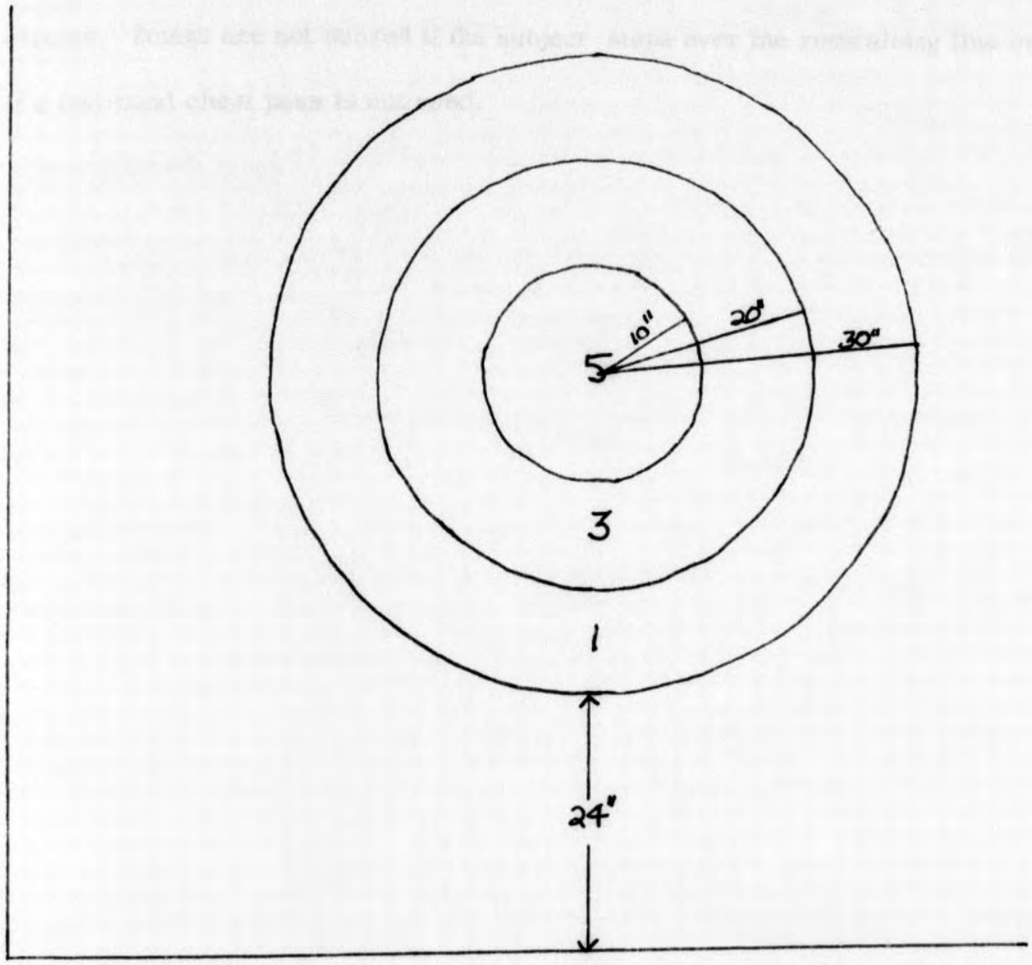
The player stands at any position she selects near the basket, with the ball in her hands. On the signal "ready, go," she starts shooting and continues to shoot until the signal to stop is given, attempting to make as many baskets as possible within the thirty seconds. If the ball has left her hand when the signal to stop sounds, the basket counts, if made. Two trials are given to each player.

Scoring. The number of baskets made in thirty seconds is the score for each trial. The better of the two trials is used in determining the score on the entire battery.

Push Pass

A three-ring concentric target was drawn on the wall, with the lower edge of the outer ring 24 inches from the floor; one-half inch black lines are used and are included within the diameter of each circle. The radii of the circles are ten, twenty, and thirty inches, respectively. The numbers five, three, and one, were placed in their respective circles, the number five being in the smallest circle.

Diagram of Wall Markings.



Instructions. The subject, with basketball in hand, stands behind a line drawn 10 feet from the wall. The test consists in passing the ball with a two-hand chest pass to the target, recovering the pass, and continuing to pass for thirty seconds. All passes must be made from behind the restraining line. The test is administered twice. The trial with the best score is used in determining the score on the entire battery.

Scoring. The subject is scored 5, 3, and 1 for hitting within the inner, middle, and outer circles, respectively. Line hits are counted for the inner circles. Points are not scored if the subject steps over the restraining line or if a two-hand chest pass is not used.

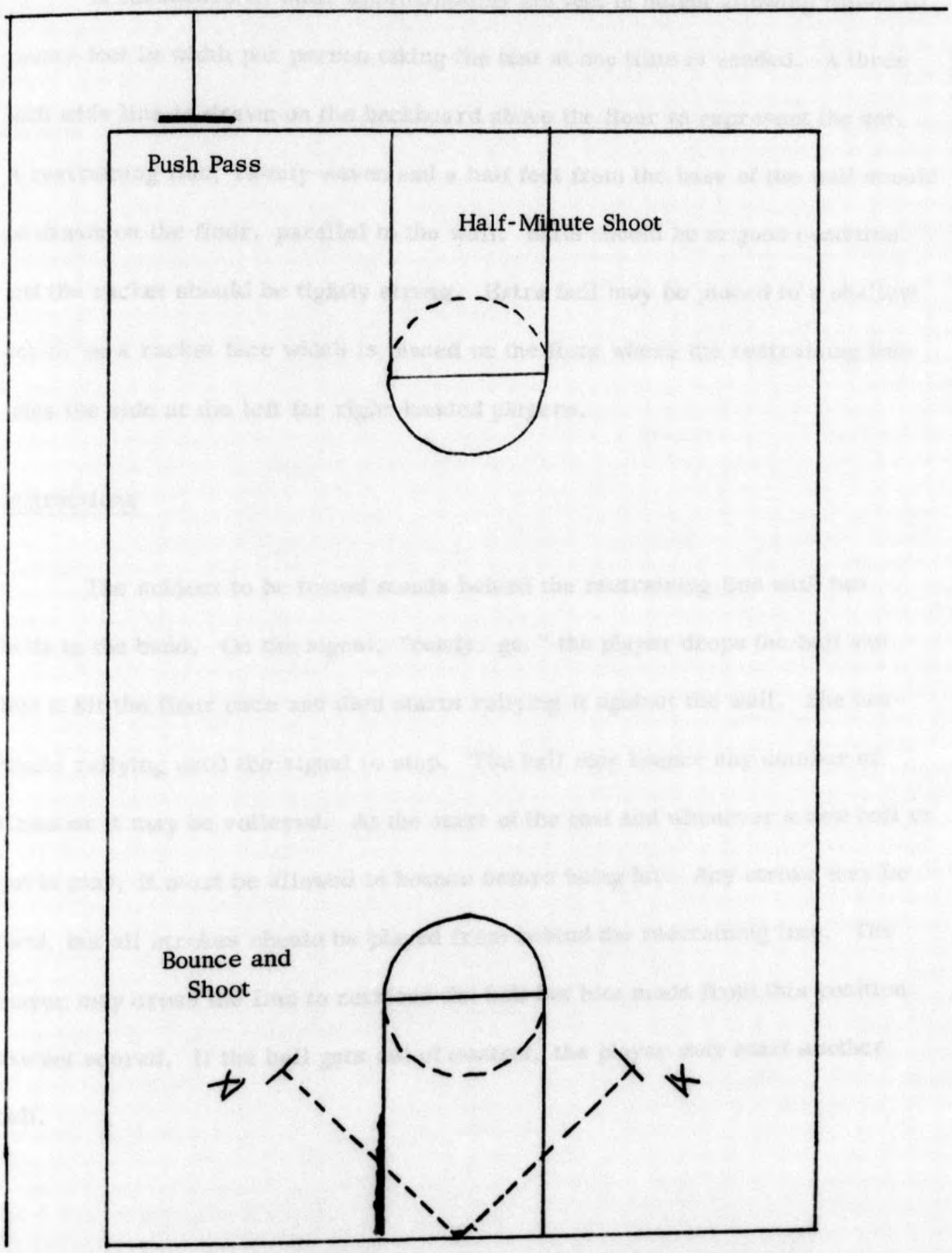
BASKETBALL SCORECARD

Name ______________________ Class ______________

				T-Score
Half-Minute Shooting	________	________		________
Push Pass	________	________		________
Bounce and Shoot	________ pts.	________ secs.	pts.	________
	________ pts.	________ secs.	secs.	________
			Total T's	________

Total T's ÷ 4 = Final Score ________

DIAGRAM OF TEST ORGANIZATION FOR LEILICH BATTERY



DESCRIPTION OF MODIFIED DYER BACKBOARD TEST(16)

A backboard or wall, approximately ten feet in height allowing fifteen to twenty feet in width per person taking the test at one time is needed. A three inch wide line is drawn on the backboard above the floor to represent the net. A restraining line, twenty-seven and a half feet from the base of the wall should be drawn on the floor, parallel to the wall. Balls should be in good condition and the racket should be tightly strung. Extra ball may be placed in a shallow box or on a racket face which is placed on the floor where the restraining line joins the side at the left for right-handed players.

Instructions

The subject to be tested stands behind the restraining line with two balls in the hand. On the signal, "ready, go," the player drops the ball and lets it hit the floor once and then starts rallying it against the wall. She continues rallying until the signal to stop. The ball may bounce any number of times or it may be volleyed. At the start of the test and whenever a new ball is put in play, it must be allowed to bounce before being hit. Any stroke may be used, but all strokes should be played from behind the restraining line. The player may cross the line to retrieve the ball but hits made from this position are not scored. If the ball gets out of control, the player may start another ball.

Scoring

Each ball striking the wall on or above the net line before the end of the thirty seconds counts as a hit and scores one point. Three trials are given, the final score being the sum of the scores on the three trials.

TABLE VII

RAW DATA

SUB.	SKILL	BALANCE STICK DOM.	BALANCE STICK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM CIRCLING	TOTAL KINESTHESIS SCORE
Basketball									
1	58	30.4	23.0	1	2	7	5	7	121.3
2	58	61.9	27.8	9	10	10	1	7	120.175
3	59	15.9	23.8	2	6	3	1	9	110.075
4	66	30.4	27.0	5	1	3	8	6	104.25
5	60	27.9	24.9	9	1	12	3	7	97.5
6	64	26.5	38.2	0	12	0	11	4	94.325
7	65	22.4	30.6	3	0	10	11	6	93.95
8	65	26.6	22.6	6	3	10	7	7	93.8
9	65	21.0	16.5	13	2	7	2	8	91.725
10	63	20.2	22.9	0	6	22	6	9	90.625

TABLE VII (continued)

SUB.	SKILL	BALANCE STICK DOM.	BALANCE STICK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM CIRCLING	TOTAL KINESTHESIS SCORE
11	60	17.9	21.7	20	4	0	1	6	82.9
12	65	28.0	16.4	13	2	12	19	9	79.9
13	57	27.3	24.0	1	6	9	5	2	76.875
14	62	16.0	12.3	3	8	12	10	8	75.825
15	61	19.0	22.9	22	9	6	3	6	69.625
16	57	28.4	28.9	0	12	8	9	1	68.675
17	66	12.3	18.4	4	5	1	8	1	59.725
18	61	20.9	20.3	10	1	16	12	1	46.6
19	65	28.8	22.0	31	12	5	2	1	42.8
20	55	14.2	17.4	23	4	9	15	3	37.55
Bowling									
21	129.8	50.9	25.4	12	9	6	6	8	116.525
22	116.8	47.5	28.6	4	4	6	5	6	116.275

TABLE VII (continued)

SUB.	SKILL	BALANCE STICK DOM.	BALANCE STICK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM CIRCLING	TOTAL KINESTHESIS SCORE
23	116.9	35.9	34.4	10	11	2	2	7	110.625
24	119.0	14.4	20.8	5	1	0	0	8	108.0
25	126.6	30.0	38.2	9	5	11	6	8	107.75
26	117.8	19.5	19.5	2	2	13	6	8	93.85
27	115.7	23.1	22.2	5	2	11	6	6	88.175
28	135.6	24.5	22.4	3	6	2	1	3	87.275
29	124.3	16.8	13.0	4	3	2	7	6	84.55
30	115.0	11.8	12.5	3	5	5	7	7	81.125
31	118.5	23.2	20.1	1	9	3	8	4	80.275
32	133.0	21.0	13.9	9	2	10	10	7	78.075
33	125.4	16.0	25.2	3	3	2	9	1	68.6
34	137.5	15.4	26.8	11	2	10	2	2	66.05

TABLE VII (continued)

SUB.	SKILL	BALANCE STICK DOM.	BALANCE STICK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM CIRCLING	TOTAL KINES-THESIS SCORE
35	115.2	24.2	26.2	5	26	14	0	4	61.6
36	135.0	18.6	19.8	8	4	8	8	2	60.2
37	130.8	19.7	29.6	5	9	14	8	1	55.675
38	119.5	17.1	24.1	17	0	10	11	1	47.6
39	120.2	19.2	14.2	16	11	11	2	1	39.75
40	118.0	23.7	16.9	31	10	9	6	2	33.85
Tennis									
41	33	92.4	34.5	11	12	3	4	6	143.375
42	43	32.6	35.0	2	8	7	4	7	112.6
43	38	22.0	33.0	11	6	6	1	9	108.55
44	37	20.0	34.6	4	8	7	7	9	107.25
45	41	34.2	31.4	3	2	6	21	8	104.8
46	41	22.3	23.5	8	16	0	3	9	99.65

TABLE VII (continued)

SUB.	SKILL	BALANCE STICK DOM.	BALANCE STICK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM RAISING	TOTAL KINESTHESIS SCORE
47	49	18.4	19.9	1	2	9	1	7	98.625
48	40	23.0	24.5	2	5	4	7	6	95.825
49	37	48.4	28.6	16	10	17	8	7	89.65
50	28	35.9	25.9	7	0	1	9	1	84.05
51	48	15.7	26.0	0	0	15	14	6	80.475
52	32	18.7	26.3	0	6	12	6	4	78.55
53	45	17.8	17.9	6	10	11	13	8	74.375
54	39	16.1	14.9	18	8	5	6	7	68.95
55	39	18.5	16.6	5	3	5	7	2	65.725
56	43	21.3	21.6	12	5	4	6	1	59.875
57	34	21.1	22.2	6	14	3	6	1	58.175
58	41	16.5	27.5	4	12	10	11	1	50.7

TABLE VII (continued)

SUB.	SKILL	BALANCE STOCK DOM.	BALANCE STOCK NONDOM.	WEIGHT SHIFTING DOM.	WEIGHT SHIFTING NONDOM.	ARM RAISING DOM.	ARM RAISING NONDOM.	ARM CIRCLING	TOTAL KINESTHESIS SCORE
59	30	19.4	15.9	13	9	6	12	3	50.575
60	31	7.5	12.3	2	1	9	8	1	49.55

TABLE VIII

RAW DATA FOR RELIABILITY TESTING

SUBJECT	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	WEIGHT SHIFTING R 2	WEIGHT SHIFTING L 1	WEIGHT SHIFTING L 2	ARM RAISING R 1	ARM RAISING R 2	ARM RAISING L 1	ARM RAISING L 2	ARM CIRCLING 1	ARM CIRCLING 2	TOTAL KINESTHESIS
1	12.4	16.7	5	7	4	1	5	1	2	2	4	6	71.625
2	14.6	11.1	12	5	2	1	1	1	5	3	4	6	64.075
3	17.2	13.8	21	12	4	6	15	5	3	5	2	1	29.65
4	15.6	21.4	1	6	17	13	5	5	5	3	1	1	46.45
5	22.5	27.6	2	5	1	5	5	3	1	1	5	5	46.075
6	48.3	43.3	6	4	6	8	6	2	1	1	6	7	124.9
7	10.2	9.6	21	51	50	48	0	1	4	2	1	1	-8.45
8	22.3	27.9	12	18	2	8	8	5	10	7	1	4	48.35
9	39.3	23.8	4	3	12	16	1	5	1	1	1	2	78.025

TABLE VIII (continued)

SUBJECT	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	WEIGHT SHIFTING R 2	WEIGHT SHIFTING L 1	WEIGHT SHIFTING L 2	ARM RAISING R 1	ARM RAISING R 2	ARM RAISING L 1	ARM RAISING L 2	ARM CIRCLING 1	ARM CIRCLING 2	TOTAL KINESTHESIS
10	18.1	17.2	36	31	5	10	1	0	5	5	6	3	49.675
11	18.1	18.8	6	2	10	1	4	0	2	0	1	4	60.375
12	27.0	20.4	1	4	4	3	3	2	5	1	1	1	74.25
13	18.3	21.2	25	13	6	8	5	7	4	1	2	2	41.025
14	26.0	30.4	1	7	6	6	1	0	3	1	1	1	85.0
15	38.5	35.2	0	27	45	45	5	3	5	0	1	1	51.975
16	20.7	20.4	24	17	0	3	10	8	0	6	1	1	37.575
17	19.5	17.5	1	7	7	4	1	1	1	0	3	6	80.85
18	22.1	26.3	17	9	1	6	0	1	1	1	6	6	93.5
19	27.4	22.1	19	5	4	15	2	0	1	0	2	3	70.525
20	23.9	33.8	22	2	5	6	5	4	8	5	1	1	48.975

TABLE VIII (continued)

SUBJECTS	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	WEIGHT SHIFTING R 2	WEIGHT SHIFTING L 1	WEIGHT SHIFTING L 2	ARM RAISING R 1	ARM RAISING R 2	ARM RAISING L 1	ARM RAISING L 2	ARM CIRCLING 1	ARM CIRCLING 2	TOTAL KINESTHESIS
21	53.3	44.7	9	2	1	5	5	5	0	5	1	1	103.2
22	16.3	18.3	8	2	6	1	7	5	2	2	1	1	50.65
23	19.5	24.0	17	14	2	5	1	6	0	0	6	9	84.825
24	20.1	14.7	2	6	10	6	2	6	5	5	1	1	50.80
25	41.0	35.4	14	19	6	3	0	0	7	7	1	1	78.0
26	23.0	16.2	2	3	6	7	7	8	9	3	6	7	46.14
27	15.9	18.0	7	6	17	12	2	2	5	9	4	7	52.225
28	25.5	23.0	3	0	4	1	0	4	3	3	5	4	92.875
29	38.0	36.2	8	22	17	7	2	4	3	3	6	8	96.85
30	10.3	10.6	16	31	33	46	0	0	4	2	1	1	15.375
31	15.1	20.4	13	3	5	2	2	2	13	11	1	1	35.325

TABLE VIII (continued)

SUB-JECTS	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	R 2	L 1	L 2	ARM RAISING R 1	R 2	L 1	L 2	ARM CIRCLING 1	2	TOTAL KINESTHESIS
32	19.2	20.7	1	3	3	16	10	7	4	5	1	1	54.625
33	16.1	14.8	18	7	7	13	6	3	1	5	1	2	37.875
34	16.5	14.5	10	2	8	12	3	2	4	4	5	7	65.75
35	19.5	19.4	25	30	45	10	8	7	11	12	7	1	4.075
36	28.0	24.1	6	2	0	3	1	3	5	2	6	7	100.275
37	13.8	16.9	15	13	10	1	3	3	4	1	6	9	65.225
38	54.3	44.0	13	4	10	10	6	4	2	1	7	9	120.7
39	34.6	37.0	4	5	5	20	2	0	5	3	2	1	94.1
40	22.9	19.7	14	15	1	6	1	5	7	7	1	1	51.65
41	13.7	14.3	16	10	15	4	9	6	2	1	3	2	36.1
42	18.9	15.6	19	7	3	4	1	1	3	7	1	1	46.575

TABLE VIII (continued)

SUBJECTS	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	R 2	L 1	L 2	ARM RAISING R 1	R 2	L 1	L 2	ARM CIRCLING 1	2	TOTAL KINESTHESIS
43	16.8	16.8	10	23	23	18	7	2	2	1	1	2	34.9
44	15.5	22.0	2	3	4	10	8	9	7	7	3	3	55.225
45	18.0	22.0	18	17	13	20	5	4	4	3	2	7	42.4
46	16.7	18.7	3	10	27	1	1	0	0	5	8	8	78.15
47	33.9	28.4	20	22	15	5	0	0	3	2	1	6	61.425
48	30.4	38.6	13	3	5	1	6	5	2	0	6	7	98.95
49	11.6	13.5	3	5	13	15	2	2	3	3	1	3	57.525
50	15.2	13.8	7	5	8	5	0	0	3	1	1	5	57.15
51	22.3	19.2	2	16	2	14	13	8	5	4	3	4	61.235
52	39.8	34.8	3	8	9	6	1	6	2	0	6	7	114.15
53	23.4	19.4	5	6	5	11	6	7	5	3	1	1	55.8

TABLE VIII (continued)

SUBJECTS	BALANCE STICK TRIALS: 1, 3, 5, 8, 10, 12	BALANCE STICK TRIALS: 2, 4, 6, 7, 9, 11	WEIGHT SHIFTING R 1	R 2	L 1	L 2	ARM RAISING R 1	R 2	L 1	L 2	ARM CIRCLING 1	2	TOTAL KINESTHESIS
54	16.1	15.0	11	10	4	5	1	0	6	5	8	9	83.925
55	13.2	29.3	35	3	15	3	7	3	7	9	3	2	19.975
56	14.0	15.8	5	4	3	0	0	3	5	3	1	1	58.05
57	12.6	10.8	7	2	7	10	1	0	2	4	2	2	55.95
58	63.9	51.2	27	32	12	8	8	8	10	10	1	1	64.025
59	10.6	15.5	12	19	11	26	2	10	10	7	1	1	22.275
60	16.5	18.5	33	26	11	3	6	2	3	2	3	7	33.35
61	17.9	15.0	6	8	15	20	5	6	4	2	1	2	31.375