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THE EFFECT OF TRAINING FOR DYNAMIC BALANCE ON BOWLING PERFORMANCE

by

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Approved by

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APPROVAL SHEET

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The purpose of this study was to determine the effect of training for dynamic balance on bowling performance. A secondary purpose was to determine the effect of training for dynamic balance on balance performance.

Twenty-seven women enrolled in four bowling classes at the University of North Carolina at Greensboro served as subjects for this study. The experimental group of fifteen subjects received training for dynamic balance in addition to regular bowling instruction; the control group of twelve subjects received only bowling instruction. A total of twenty-seven subjects completed the study.

The four bowling classes were taught by the author and received the same instruction. The method of instruction stressed spot bowling using the four step approach and the straight ball delivery. Classes met twice a week for seventeen weeks.

The subjects were measured on dynamic balance and bowling performance. The Bass Test of Dynamic Balance and the Sideward Leap Test were used as measures of dynamic balance. The totals of the first and last five lines were used as measures of bowling performance on the pre-test and post-test, respectively. The testing in dynamic balance was conducted after five lines of bowling had been completed, and again after a total of twenty-one lines had been bowled.

The covariance design was used to determine the effect of training for dynamic balance on bowling performance and the effect of training for dynamic balance on balance performance. The only result found statistically significant was obtained on the Bass Test of Dynamic Balance. This significant F was in favor of the experimental group.

Fisher's "t" test of significance of difference between means for small correlated groups was used to determine if any significant difference existed within groups in regard to bowling and dynamic balance. Each group improved significantly in bowling performance, the Bass Test of Dynamic Balance, and the Sideward Leap Test.

Within the limitations of this study, the following conclusions were made:

1. Bowling performance at the beginning level was not improved significantly by a training program in dynamic balance.
2. Training for dynamic balance improved balance performance on the Bass Test of Dynamic Balance.
3. Training for dynamic balance did not improve balance performance on the Sideward Leap Test.

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CHAPTER I

INTRODUCTION

It is recognized by physical educators that balance plays an important role in the performance of various motor skills. Gross and Thompson have stated:

> The ability to maintain one's balance under various circumstances is recognized as one of the basic motor skills. It is an essential factor in movements made in numerous sports and physical education activities. The optimum balance for each sport performance results from the use of the stance best adapted to the particular skills involved in that sport. Hence, balance is an important factor in batting, throwing, and fielding in softball; forehand and backhand drives in tennis; all strokes in golf; line play in football; dribbling and shooting in basketball; building pyramids in gymnastics; etc. (38:342)

Balance is stressed as one of the key factors in effective bowling, and the ability to maintain equilibrium while moving and immediately following movement has considerable effect on bowling performance. (3,60) Although there are many variations in the approach and delivery used by successful bowlers, most of today's well-known performers recognize and stress the importance of balance as a basic factor in good bowling. (3, 6, 7, 9, 10, 11, 13, 19, 25, 44) The bowler must set his body and the ball in motion, maintain balance while sliding to a stop, and smoothly deliver the ball onto the alley. The completely balanced and relaxed stance; the coordinated pushaway and weight shift; the correct timing and rhythm; the delivery incorporating good balance and coordination of the hands and feet; the smooth, full, well-balanced follow-through -- all are parts of an integrated whole.

A review of the studies relating balance to bowling indicated a need for additional research. If balance plays an important role in physical activity, it would appear possible to improve performance by improving balance. This study was undertaken to determine if a prescribed series of balance exercises would affect bowling performance.

CHAPTER II

STATEMENT OF PROBLEM

The purpose of this study was to determine the effect of training for dynamic balance on bowling performance. A secondary purpose was to determine the effect of training for dynamic balance on balance performance.

The subjects were twenty-seven college women enrolled in four bowling classes at the University of North Carolina at Greensboro during the spring semester of the 1964-65 school year. In addition to regular bowling instruction, the experimental subjects received instruction in the principles of balance and participated in exercises utilizing these principles. The control subjects received only class instruction.

It was necessary to obtain a measure of balance and bowling in order to conduct the study. Balance ability was measured by two tests of dynamic balance -- the Bass Test of Dynamic Balance and the Sideward Leap Test. The initial score in bowling was designated as a total of the first five lines. The final score was designated as a total of the last five lines.

I. DEFINITIONS

For the purpose of this study, the following definitions were accepted:

Beginning bowler.--One who had bowled a maximum of ten lines with three or less of these lines having been bowled within the last three years. No formal instruction had been received.

Dynamic balance.--Keeping one's equilibrium from one balanced position to another. (29)

Static balance.--The equilibrium that is maintained for one position of the body. (29)

Line.--A game of ten frames.

II. LIMITATIONS

1. Since it was impossible to select subjects at random, the results of this study are applicable only to the subjects in this study.

2. The lesson plans for the balance program were devised solely by the author without benefit of jury or previous evaluation.

CHAPTER III

REVIEW OF LITERATURE

For the purpose of this study, an investigation was made of the literature relating to the definition and nature of balance, the relationship of balance to kinesthesis, the study of balance, the measurement of balance, and the relationship of balance to bowling.

I. DEFINITION AND NATURE OF BALANCE

Balance has long been considered an important element of motor performance. The significance of good balance has been stressed from the standpoint of skill and safety. (23)

Balance is usually considered to have two components -- static balance and dynamic balance. Generally, static balance is defined as that balance in which equilibrium is maintained. Dynamic balance is generally defined as that balance necessary in maintaining equilibrium while in motion.

Static balance has been interpreted by Bass as ". . . that balance in which the equilibrium is maintained for one position of the body." (29:33) McCloy (17) interpreted static balance as the type in which the movements and the adjustments to the movements are small. Willgoose defined static balance as ". . . the ability to maintain a specified position . . . ." (27:249)

Dynamic balance was defined by Travis as ". . . the re-orientation of the body or re-establishment of equilibrium after the body has been thrown off balance in relation to gravity." (54:216) Bass defined dynamic balance as ". . . that pertaining to the equilibrium evidenced through a series of changing positions taken successively." (29:33)

McCloy (17) suggested that the same elements are involved in static and dynamic balance, but to varying degrees. In physical activities balance depends on:

> (1) Kinesthetic responses, both sensory and motor. These responses are probably compounded physiologically of both joint sense and muscle sense. Since they seem always to work together, however, they appear in analyses as one element.
>
> (2) Visual responses, or the aid that is obtained from the eyes.
>
> (3) The semicircular canal system. The part that the semicircular canals play in the finer forms of balance is still an unanswered question. There is some statistical evidence to indicate that these canals, with the ampullae, function separately as well as together in certain forms of balance. (17:103)

Composing the labyrinths of the inner ear are the cochlea, saccule, utricle, and semicircular canals. The functioning of the saccule and utricle is affected by the static equilibrium of the head and body. These tiny chambers have end organs which are in contact with sensory nerve fibers. Inside each chamber is a cluster of otoliths, which are composed of a calcium carbonate concentration. Any altered position of the head causes the otoliths to stimulate the hair-like nerve fibers causing a sense of imbalance. This phenomenon is aided by vision.

The semicircular canals are six in number, three in each labyrinth. One end of each is expanded to form a swelling called the ampulla which contains the receptors of the equilibratory sense. Some of the receptors of the vestibular branch of the eighth cranial nerve lie in each ampulla; the vestibular nerve conveys impulses to the medulla oblongata and from there to various parts of the brain. The receptors of the semicircular canals are stimulated by a quick rotary movement of the body as a whole, or by a sudden turn of the head alone. According to Anthony (1), the stimulation of receptors in the semicircular canals and the utricles initiates righting reflexes essential for balance. De Coursey (8) described the semicircular canals as being primarily involved in sudden changes of position, either in a straight line or in rotation.

In order to maintain balance, there must be constant muscular activity which is controlled by the central nervous system. (2) Muscles respond to various stimuli by changing their tension. The stimuli are picked up by the various organs, and impulses are sent through the central nervous system to the muscles for action. (26)

The sensory organs are receptors that are responsible for receiving the stimuli in order to maintain balance. They include the organs of vision; the labyrinth organs in the inner ear, the semicircular canals; end organs of the kinesthetic sense; and the proprioceptors, sense organs in the muscles, tendons, joints, and skin. (5)

The eyes serve as a frame of reference in helping one to judge distance and detect movement of objects. According to McCurdy and Larson, "Vision is a dominant factor in maintaining equilibrium." (18:241)

The proprioceptors are the receptors found in the skin, joints, tendons, and muscles. These receptors react to messages sent to the cerebellum and to the elements of touch and pressure. (2)

Many experiments have been performed indicating that the vestibular apparatus plays an essential part in the maintenance of balance. Bass (29) considered muscle tonus and static and dynamic balance as functions of the vestibular labyrinth.

In a study on static equilibrium and vestibular function, Birren (30) supported the view that the receptors in the labyrinth are insensitive to fine body movements and that a functional loss of the receptors would not impair the response to movements associated with body sway. The results of the study indicated that man may maintain stable posture in spite of loss of vestibular function.

Whipple (55), investigating balance and walking in the treatment of cerebral palsy, indicated the importance of the eyes, the eighth cranial nerve of the cerebellum, and the semicircular canals in balance, but also stated that there must be an equal distribution of muscle, strength, control, and relaxation for balance to be adequately maintained.

Edwards (32) implied a cooperative action of the vestibule and the semicircular canals in the measurement of static ataxia. The action of the cerebellum, skin, muscles, joint senses, visual sensations, conditions of the muscular or nervous system, and conditions of the cerebrum were cited as important factors in the maintenance of equilibrium.

II. RELATIONSHIP OF BALANCE TO KINESTHESIS

Balance appears to be an integral component of kinesthesis, and kinesthesis is recognized as an important aspect of physical education. Scott stated that balance is ". . . a specific function of kinesthesis and has shown up favorably in every study that has been made with a balance test included." (49:337) She advised the inclusion of a balance test in any kinesthesis battery.

In general, kinesthesis can be defined as the position sense. Young defined kinesthesis as ". . . the cognizance of bodily position and movements, i.e., the sense of muscular efforts." (57:277) The definition given by Phillips was ". . . the process of cognizing bodily tension and/or movement on the basis of what one is doing." (46:571) In a study on dynamic kinesthetic perception and adjustment, Henry gave his definition as ". . . the perception or consciousness of one's own muscular responses." (40:177) Estep defined kinesthesis as ". . . the sense which furnishes information about the position and movement of body parts by means of sense organs located in the muscles, tendons and joints." (34:5) Phillips and Summers defined kinesthetic perception as ". . . the conscious awareness of the individual of the position of the parts of the body during voluntary movement." (47:456) Wells considered kinesthetic awareness as ". . . awareness stemming from the feelings in your muscles and joints. . . ." (24:74)

Wiebe (56) suggested that the receptors of kinesthesis are located in the muscles, tendons, and joints. Phillips inferred that the suggestions of kinesthesis are received through ". . . any or all of the mechanical senses." (46:572) 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 of 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. (63:2)

Wiebe (56) pointed out the importance of kinesthesis in regard to physical education. The functions and components of kinesthesis, which include balance, were given as important elements and concepts involved in the teaching of physical skills.

Bass (29), in an analysis of the components of tests of semicircular canal function and static and dynamic balance, found the second factor to be kinesthesis, as well as finding a loading of this factor in almost all of her balance tests.

In regard to studying kinesthesis in relation to selected movements, several studies have included balance tests. (56, 57, 62) Using selected movements commonly used in gymnastics, Young (57) administered nineteen different tests to thirty-seven college women. Arm raising sideward to 90° and leg raising to 20° were combined to give a reliability coefficient of .919. By adding a balance test, the coefficient was raised to .984.

Wiebe (56) administered twenty-one tests of kinesthesis to fifteen college varsity men and fifteen non-varsity men. He recommended the balance lengthwise test, leg raising, vertical space, and separate feet tests for further use. The results of the study indicated that there was a kinesthetic difference in favor of athletes.

Roloff (62), studying kinesthesis in relation to the learning of selected motor skills, administered eight of the tests from the Scott research project to two hundred college women whose mean motor ability T-score was 50.46. From these eight tests a battery of four tests was selected, including Balance Stick, Arm Raising, Leg Raising, and Leg Leap.

Mumby (45) found that kinesthetic acuity was measured by the ability of the subject to maintain a constant muscular pressure under a changing dynamic condition. Balance was measured by a stabilometer on which the individual was positioned in a wrestling crouch on his hands and knees. In balance, and in the ability to learn to balance, good wrestlers were somewhat better than poor wrestlers. However, balance and learning to balance were not correlated significantly with judges' ratings of the ability of the subjects to handle themselves physically in wrestling situations.

III. STUDY OF BALANCE

A number of investigators have found balance to be a factor in gross physical proficiency and psychomotor skill. (37, 39, 43, 52) From the standpoint of skill and safety, good balance is stressed as important; it is possible that erratic performance of certain skills, tension in trying to perform static activities, and poor performance on varying activities may be attributed to poor balance. (23)

McCloy (42) listed balance as one of the sixteen factors found in motor educability. According to the study, the functions of balance depend upon factors which include contribution of the eyes to balance; use of the eyes when the movement is back and forth, as when standing on a narrow beam crosswise; use of the eyes when balance involves motion sideways, as when a beam runs lengthwise to the foot; kinesthetic sensitivity;

the balance mechanism of the two vertical sets of semicircular canals; the balance mechanism of the horizontal semicircular canals; and ". . . 'tension giving reinforcement' . . ." (42:35), which is ". . . the result of a heightened sensitivity of the balance mechanisms brought on by the increasing tension on the sole of the foot." (42:36) This last factor, according to McCloy, needed further confirmation.

In one of the studies by Bass (29), the factors in balance were found to be (a) a general eye-motor factor, (b) general kinesthetic response or sensitivity, (c) general ampullar sensitivity, (d) function of the two vertical semicircular canals, (e) tension giving reinforcement, and four other factors, one of which was discarded. She also devised a Stepping Stone Test of Dynamic Balance with a reliability of r = .952 and a Stick Balance Test of Static Balance with a reliability ranging from r = .72 to r = .90. Bass found a significant relationship between dynamic balance and general motor ability, as well as rhythm.

Gross and Thompson (38) studied seventy-eight advanced swimmers, all of whom were taught nine swimming strokes and put through a conditioning program during a six-week period. The subjects were then rated on their ability to swim the nine strokes, timed three separate times for the 30-yard sprint in swimming, and given the Bass Stepping Stone Test of Dynamic Balance. In general, the individuals who had better dynamic balance could swim faster than individuals who had poor dynamic balance. The individuals with better swimming ability, as determined by expert judgment, tended to have better dynamic balance than individuals with poor swimming ability. It was concluded that dynamic balance was not a chance factor, but was important in speed and ability in swimming.

Travis (54) found that the dynamic component of equilibrium was quite unrelated to the static component. The lack of relationship was indicated by the practically zero correlation between performance on the stabilometer and the amount of body sway at the head in the standing position. Both static and dynamic balance were aided greatly when visual cues were present. Mild exercise had little effect on the dynamic stabilometer performance, but increased body sway significantly due to the increase in respiration which in turn increased the head movements.

Estep (34) investigated the relationship between static equilibrium and ability in gross motor activities. The Miles Ataxiameter was used to measure static equilibrium. Estep concluded that the results obtained supported the hypothesis that there is a positive relationship between static equilibrium and ability in gross motor activities.

Espenschade, Dable, and Schoendube (33), using a group of fifty-eight boys, studied dynamic balance by means of ten foot walking beams. The children consistently improved in balance between eleven and sixteen years of age, but the rate of gain between thirteen and fifteen was noticeably retarded. It was concluded that growth in dynamic balance is retarded at puberty. In this study dynamic balance was not related to height and weight but correlated substantially with physical abilities important in the physical education program.

Cron and Pronko (31) studied the dynamic balance of 501 children in summer playgrounds. The children were four to fifteen years of age; there were 322 boys and 179 girls. The balance board was ". . . a two-by-four twelve feet long, supported on edge four inches from either end, two inches from the ground." (31:33) One point was scored for each complete trip with a maximum of six points. The ability of the children to walk the balance board increased from the four to six age groups to the eleven to twelve age groups. It then leveled off and showed a slight decrease in the twelve to fifteen age group. These results also indicated that balance improves with age. It appeared that the older the child, the smoother the performance looked. Girls were better than boys in age groups four to eight, while the boys were better from eight to fifteen.

Adrian, as cited by Seashore (52), administered a battery of balance and steadiness tests to two groups of college men who had been divided on the basis of their athletic ability. The tests used were the Miles Ataxiameter, Whipple Steadiness, Balance Platform, and Leg Dynamometer. The data on the Balance Platform ". . . were ambigious." (52:264) The leg strength test indicated that athletes were superior in gross motor ability. There was no difference between the two groups on the finer motor coordinations of postural sway and steadiness of hand.

Lafuse (41), in studying the learning of fundamental skills by college freshman women of low motor ability, concluded that students who scored in the lower quartile group on the Scott Motor

Ability Battery made scores significantly lower on balance than those students in the upper quartile group.

Garrison (58) found a low but positive relationship between motor ability and balance in college women. She also found that dynamic balance of college women can be improved through balance exercises.

Fisher, Birren, and Leggett (36) investigated two tests of equilibrium. The railwalking test was used to measure dynamic equilibrium; the ataxiagraph was used to measure body sway. The authors found a zero correlation between the two tests. In addition, practice on the railwalking test with eighteen subjects and eight trials resulted in eighty-nine per cent improvement, while the ataxiagraph, with seven subjects and ten trials, showed an improvement of eighty-nine per cent with eyes open and thirteen per cent with eyes closed. The differences showed that different sensiomotor performances were being measured.

IV. MEASUREMENT OF BALANCE

Willgoose (27) described three tests of balance, two of which measured static balance while the other was a measure of dynamic balance. During the divers stance, the subject closes his eyes and stands on his toes for twenty seconds. In the squat stand, the subject squats, places his elbows against the medial surfaces of the knees, leans forward raising his feet off the floor, and holds the position for five seconds. The test of dynamic balance is one of dizziness recovery in which the subject walks a straight line after turning around his finger on the floor.

The Springfield Beam-Walking Test, developed by Seashore (51), measures the ability to maintain balance when walking beams of various widths. The apparatus includes nine oak beams, each ten feet long, four and one-half inches from the floor, and ranging in width from four inches to one-half inch. Each beam is marked in quarter lengths. The subjects, hands on hips and starting at a specified mark, must take ten steps without falling off the beam, stepping crosswise, or taking his hands from the hips. Seashore found that the reliabilities ranged from r = .85 to r = .89 for the ages five to eighteen. He concluded that the beam-walking test, as a measure of dynamic balance, offered standardized apparatus and was applicable to the whole range of school ages with reasonable reliability.

The Collins-Howe Test of Static Balance (17) utilizes a balance board resembling a short seesaw with two side boards, which run from the ends of this board upward to another board pivoted above the subject's head. There are handles on the sides for the hands to grasp. The score is obtained by a work adder under one side to count the excursions. This is an excellent laboratory method but requires much administration time.

Two other tests of balance are the Bass Stick Test of Static Balance and the Bass Test of Dynamic Balance, or the Stepping Stone Test. (29) In the Stick Test the subject stands with one foot lengthwise on the stick which is one inch high, one inch wide, and twelve inches long. The number of times the subject steps off within a one-minute period is recorded. The same type recording is made with the subject standing with the foot crosswise on the stick. The total test consists of twelve items. Bass gave the reliability coefficients as ranging from .721 to .901. When the items of the Stick Test of Static Balance were correlated with the Seashore Sense of Rhythm Test, the coefficients ranged from .195 to .496. When the twelve items of the Stick Test were correlated with general motor rating, the coefficients ranged from .221 to .505.

In the Bass Test of Dynamic Balance (29), the subject must leap into each of ten circles laid out on the floor, land on the ball of the foot, and remain in each circle for five seconds. One penalty point is scored each time any one of the errors is committed. Bass gave the reliability of this test as r = .952. When the dynamic balance test was correlated with rhythm judgment, the coefficient was .739. When the test was correlated with motor judgment, the correlation was r = .687.

Scott (23) investigated the Sideward Leap Test involving balance in two successive movements in planes at right angles to each other. The test consists of hopping sideward, bending forward, flicking a cork off a spot, and holding the balanced position for five seconds. Three trials are given to the right and three to the left; then the trials to the right and left are repeated. The score is the total time the balance is held for the twelve trials. The validity was r = .73. The reliability of the Sideward Leap Test was found to be r = .88 when the test was given to 116 college women. The test was combined with the Balance on a Stick Test into a battery using 1.3 Sideward Leap + 1.0 Balance on Stick. (23)

V. RELATIONSHIP OF BALANCE AND BOWLING

In studying the mechanics of bowling, McKee listed the following as facts and principles involved in maintaining balance in bowling:

1. A body is in equilibrium when its center of gravity is over the base of support.

2. When an object is held in the hand its weight must be considered as part of the body weight to be balanced over the base of support.

3. For every action there is an equal and opposite reaction. When accelerating, the body must move forward to balance the forces in the opposite direction.

   When the upper part of the body is ahead of the body's center of gravity, a moment of force is created.

4. The wider the base of support, the more stable the object.

5. Stability is increased if the widest part of the base is in the direction of the force which is attempting to disturb equilibrium.

6. Force may be diminished by increasing the distance over which it is absorbed. (44:18)

There have been many successful bowlers who have stressed the importance of balance in effective bowling. (3, 6, 7, 9, 10, 11, 13, 19, 25) Wene stated that "The secret of bowling is balance. This means being in control of your body from the moment you take your starting stance until you have completed your follow-through. If you lose your balance, you necessarily must lose control of the ball." (25:31)

Fraley (11) considered comfort the most important part of the starting position as long as the body balance was retained. McMahon and Goodman (19) stressed the importance of the feet and shoulders facing the pins squarely and the bowler being completely balanced, relaxed, and concentrating as he prepares to bowl. Falcaro and Goodman (9) stressed the importance of a state of perfect balance and complete harmony, with no upset in balance on the approach.

Greenlee (60), in a study on the relationship of selected measures of strength, balance, and kinesthesis to bowling performance, concluded that there is a positive relationship between dynamic balance and bowling performance. She found that dynamic balance, as measured by the Sideward Leap Test, had a correlation of $r = .316$ with bowling performance which was significant at better than the one per cent level of significance.

VI. SUMMARY OF FINDINGS

In general, both static and dynamic balance have been shown to be related to general motor ability. There is agreement that the maintenance of balance under various physical circumstances is a basic motor skill, and balance has been stressed in regard to skill and safety during participation in activity.

Many investigators have found balance to be a factor in gross physical proficiency and psychomotor skill. McCloy; Bass; Estep; Espenschade, Dable, and Schoendube; Lafuse; and Garrison have found a relationship between balance and motor educability, motor ability, and gross motor activities.

It is widely recognized that the maintenance of balance is dependent upon the organs of vision, the semicircular canals, the end organs of the kinesthetic sense, and the proprioceptors.

Closely related to balance is the proprioceptive or kinesthetic consciousness of the body in movement. As balance appears to be such an integral component of kinesthesis, the inclusion of a balance test in any kinesthetic battery has been advised. (49)

Evidence indicates that balance generally improves with age. Espenschade, Dable, and Schoendube found that children consistently improved in balance between eleven and sixteen years; but the rate of gain between thirteen and fifteen was noticeably retarded, indicating growth in dynamic balance is retarded in puberty. Cron and Pronko also supported the opinion that balance improves with age.

Balance can be measured reliably. The Seashore Beam-Walking Test, Collins-Howe Test of Static Balance, Bass Stick Test of Static Balance, Bass Test of Dynamic Balance, and Sideward Leap Test have all been used successfully in measuring performance consistently.

Successful bowlers have long stressed the importance of balance in bowling. Generally, good balance is considered necessary throughout the stance, approach, and delivery for the bowler's performance to be effective.

Evidence supporting a positive relationship between dynamic balance and bowling has been presented by Greenlee. However, more research is needed in relating balance to bowling. If a positive relationship exists between dynamic balance and bowling, it would appear valuable to investigate the effect of training for dynamic balance on bowling performance.

CHAPTER IV

PROCEDURE

The purpose of this study was to determine the effect of training for dynamic balance on bowling performance. A secondary purpose was to determine the effect of training for dynamic balance on balance performance.

I. SELECTION OF TESTS

The dynamic balance tests used in this study were the Bass Test of Dynamic Balance and the Sideward Leap Test. These two tests were selected on the basis of their value as shown by previous studies. An attempt was made to select tests which were appropriate for the age level, easy to administer and score, and economical of time required for administration. The description and directions, diagram, and score card for the Bass Test of Dynamic Balance are given in Appendix A. The description and directions, diagram, and score card for the Sideward Leap Test are given in Appendix B.

The Bass Test of Dynamic Balance and the Sideward Leap Test were first correlated to determine if both tests measured balance in the same way. Using the Pearson Product-Moment method of correlation, an r of .582 was obtained. The coefficient was large enough to indicate considerable relationship between the

Bass Test of Dynamic Balance and the Sideward Leap Test as measures of dynamic balance. However, the author thought that the coefficient was not sufficiently high to warrant the use of either test exclusive of the other. The coefficient indicated, to a certain extent, that the tests were measuring different aspects of dynamic balance.

Bass Test of Dynamic Balance

The most reliable and valid measure of dynamic balance was found to be the Bass Test of Dynamic Balance which required little equipment and was easily administered. Bass gave the reliability of this test as r = .952. When the test was correlated with rhythm judgment, the coefficient was .739; when the test was correlated with motor judgment, the correlation was r = .687. (29)

Sideward Leap Test

The Sideward Leap Test required little equipment and was easily administered. Scott gave the validity of the test as r = .73 with a composite criterion of balance. The reliability was found to be r = .88 when the test was given to 116 college women. (23)

II. SELECTION OF SUBJECTS

The subjects were twenty-seven freshman and sophomore women enrolled in four bowling service classes during the spring semester of 1964-65 at the University of North Carolina at Greensboro.

Originally, there were twenty-nine subjects in the experiment. One of the subjects in the Monday-Friday class was eliminated from the study because of illness; one of the subjects in the Monday-Wednesday afternoon class was eliminated from the study because she did not participate in the final balance testing.

Subjects were selected on the basis of classification as beginning bowlers. Beginning bowlers were designated as those who had bowled a maximum of ten lines with three or less of these lines having been bowled within the last three years. None of the subjects qualifying as beginning bowlers had ever received formal instruction in bowling. The subjects' status as beginning bowlers was assessed from the information obtained from a questionnaire given all students on the first day of class. An example of the questionnaire may be found in Appendix D.

The author met with all subjects to briefly describe the experiment. During this time the subjects were told that they would be asked to participate in a pre-test and post-test for measuring their ability to balance. It was also explained to the experimental subjects that the balance training would be conducted for fifteen minutes prior to their regular bowling classes. All students at the meeting agreed to participate. The specific information presented to each group may be found in Appendix E.

Four sections of bowling were used in this study; two were designated as experimental groups by the roll of a die, and two were assigned as control groups. It was necessary to select randomly by class because of the difficulty of changing the schedules.

In both experimental and control groups there was an afternoon and a morning section. One control class met Monday and Wednesday at 9:00 a.m., and the other control class met Monday and Wednesday at 4:00 p.m. One experimental class met on Monday and Friday at 8:00 a.m., and the other experimental class met on Tuesday and Thursday at 4:00 p.m. The author taught all four bowling classes.

The number of subjects in each class was as follows:

		Subjects	Other Students
Monday-Friday	8:00 a.m. - experimental	5	10
Tuesday-Thursday	4:00 p.m. - experimental	10	8
Monday-Wednesday	9:00 a.m. - control	9	10
Monday-Wednesday	4:00 p.m. - control	3	12

III. CONDUCT OF EXPERIMENT

All bowling classes received the same instruction and method of presentation. The method of instruction stressed spot bowling using the straight ball delivery and four step approach.

Because of the number of students in each class, half of the students in each class came on the hour and the other half came on the half hour with each group bowling for a period of thirty minutes. Four lanes were available with three or four students assigned to each lane.

The experimental groups met for fifteen minutes of balance training before each of their regular class sessions. This balance training began after five lines had been bowled, and the sessions were held twice a week for a period of nine weeks.

The balance lessons were devised to include exercises which primarily involved dynamic balance although some exercises included static balance. Such principles of balance as the center of gravity, line of gravity, size of the base of support, external weights, use of the eyes, and use of the arms were taught. The subjects were encouraged to get the feel of balance and to use the feeling when practicing the exercises. The author taught the balance exercises. The balance lesson plans may be found in Appendix F.

The following conditions were the same for all students:

1. No subject was absent more than three times during the study.
2. The author taught all bowling classes.
3. All subjects bowled a total of twenty-one games.

IV. ADMINISTRATION OF TESTS

Balance

Each subject was asked to sign up for a quarter hour period on one of the two evenings during which the preliminary testing was conducted. The testing was held in the Golf Room of Coleman Gymnasium. During the testing, the subjects progressed from the Bass Test of Dynamic Balance to the Sideward Leap Test. Graduate students assisted in timing, scoring, and administering the tests. A diagram of the test organization may be found in Appendix C.

In the Bass Test of Dynamic Balance the subject must leap into each of ten circles laid out on the floor, land on the ball of the foot, and remain in each circle for five seconds. One penalty point was scored each time any one of the errors was committed. The errors included lowering the heel to the floor, touching the boundary lines of the circles, touching the other foot to the floor, moving the foot while in the circle, hopping on the foot in the circle, touching the floor outside the circle, and touching the floor with any other part of the body.

The test and errors were explained and demonstrated by the test administrators. Each subject performed the test five times; after three practice trials, the better of the next two trials was scored. This method was interpreted as taking the best of five trials for scoring. (29) The total amount of time and the number of errors were recorded after each of the five trials. The majority of subjects wore gymnasium costumes and tennis shoes during the testing; it was not believed that the performance of the few subjects who were not dressed in gymnasium costumes was significantly affected.

The Sideward Leap Test consists of hopping sideward, bending forward, flicking a cork off a spot, and holding the balanced position for five seconds. A failure was scored if the subject failed to leap to the designated mark, moved the foot after landing on the mark, did not lean forward and move the cork immediately, rested the hand on the floor, or fell down.

The test was explained and demonstrated by the test administrators. Each subject was given three trials to the right and three to the left; then the trials to the right and left were repeated. The number of seconds the balance was held was recorded after each leap. The majority of subjects wore gymnasium costumes and tennis shoes during the testing; it was not believed that the performance of the few subjects who were not dressed in gymnasium costumes was significantly affected.

Two stations were used for the Bass Test of Dynamic Balance and two for the Sideward Leap Test with a total of six administrators scoring, timing, and recording errors. Each subject was given the explanation and demonstration for the Bass Test of Dynamic Balance before the test was administered. After taking this test, the subject moved to the Sideward Leap stations where the same procedure was followed.

Two administrators were at each station for the Bass Test of Dynamic Balance, and one administrator was at each Sideward Leap station. The Bass Test of Dynamic Balance was administered by a scorer and a timer. In an effort to maintain objectivity, the same scorers scored all of the performances on the Bass Test of Dynamic Balance. Using a stopwatch, the same timers counted the seconds aloud according to the directions for the test. (29)

The subjects were administered the two tests of dynamic balance after the completion of five lines of bowling. During the next nine weeks, regular bowling classes were conducted with the experimental groups participating in balance training. At the end of nine weeks, the two tests of dynamic balance were readministered with the same administrators, equipment, demonstrations, and explanations. The subjects reported to the same stations for the pre-tests and post-tests in order that, on both occasions, balance be measured under the same administrators.

Bowling

For this study the score for each subject was totaled for games one through five (pre-test) and sixteen through twenty-one (post-test) as a measure of bowling performance. The pre-tests and post-tests in balance were calculated as measures of balance performance.

In order to determine the number of games to be used in obtaining pre-and-post performance scores, the Pearson Product-Moment method of correlation was used on bowling scores of thirty-eight students in 1963-64 at the University of North Carolina at Greensboro. All possible combinations of averages of the first five games and first three games with averages of the last five games, last three games, and first three out of last five games were correlated. The highest correlation was found between the average of the first five games and the average of the last five games. All correlation coefficients are shown in Appendix G.

V. TREATMENT OF DATA

The covariance design was used to determine the effect of training for dynamic balance on bowling performance and the effect of training for dynamic balance on balance performance on the two separate balance tests. This design was selected because it removes, to the extent that they can be predicted, differences between individuals which existed prior to the experiment. (22)

Fisher's "t" test of significance of difference between means for small correlated groups was used to determine if any significant difference existed within groups in regard to bowling and dynamic balance scores.

CHAPTER V

ANALYSIS AND INTERPRETATION OF DATA

The purpose of this study was to determine the effect of training for dynamic balance on bowling performance. A secondary purpose was to determine the effect of training for dynamic balance on balance performance.

I. PRESENTATION OF DATA

Bowling classes participating in the study were randomly assigned to the experimental or control group by the roll of a die. As the analysis of covariance provides for an adjustment between the initial and final scores, the groups were not matched or equated. If the correlation between the adjusting and dependent variables is significant, the covariance design is justified. Therefore, tests for the significance of regression were made. Pre-test and post-test scores yielded measures of the adjusting and dependent variables, respectively. The classes were given a pre-test, the conditions were imposed, and a post-test was administered. In this chapter the analysis of the data for each of the three tests will be discussed on the basis of the main analysis of covariance. When the main analysis of covariance was significant, the adjusted sample means are discussed. For the tests of significance, the five per cent level of significance was used as the criterion value.

Fisher's "t" test of significance of difference between means for small correlated groups was used to compare performance within each group on the two administrations of the Bass Test of Dynamic Balance and the Sideward Leap Test as well as bowling performance as evidenced by the difference between pre-test and post-test scores.

Between Group Comparison

Bowling. One of the assumptions of the covariance design is that there is a significant correlation between the dependent variable and the adjusting variable. The test of significance of regression resulted in an F value of 9.645 which was greater than the criterion value of F, 4.26. The null hypothesis was rejected.

The main analysis of covariance yielded an F value of .008. As this F was less than the criterion value of 4.26, the null hypothesis was accepted, indicating no difference in bowling performance between the experimental and control groups. The data for this analysis are reported in Table I.

Table II reports the results of the tests of non-additivity of the sample variances and the sample regressions. The test of additivity of the sample variances showed that the treatment effects were constant and additive. The test of additivity of the sample regressions indicated that the sample regressions were heterogeneous.

TABLE I

ANALYSIS OF COVARIANCE OF DATA FOR BOWLING SCORES

Component of Variability	SS	df	V	F	F_c
Treatment	34.054	1	34.054	.008	4.26
Error	103787.158	24	4324.465		
Total	103821.212	25			

TABLE II

TESTS OF NONADDITIVITY FOR BOWLING SCORES

	F	F_c
Sample Variances	2.666	3.09
Sample Regressions	10.013*	4.28

*Null hypothesis rejected at 5% level of significance.

Bass Test of Dynamic Balance. The test of significance of regression yielded an F value which was large enough to reject the null hypothesis at the five per cent level of significance. This justified the use of the analysis of covariance. The obtained F was 22.811 and the criterion value of F was 4.26.

In the main analysis of covariance, shown in Table III, the F value of 4.40 exceeded the criterion value of 4.26. The null hypothesis was rejected. It was assumed that the differences were produced by the treatment effects.

Table IV shows the results of the tests of nonadditivity of the sample variances and the sample regressions. Both tests of nonadditivity had to be rejected. Therefore, the assumption that the treatment effects were constant and additive and that the sample regressions were homogeneous are not tenable.

The adjustment of the sample means indicated that the experimental group showed the greater improvement. These results are reported in Table V.

Sideward Leap Test. The test of significance of regression of the dependent and the adjusting variables resulted in an F value of 41.376 which was greater than the criterion value of F, 4.26. The null hypothesis was rejected, indicating that the correlation was due to something other than chance.

Table VI presents the main analysis of covariance; the null hypothesis was accepted because the F value, .013, was less than the criterion value of F, 4.26. This acceptance indicated

TABLE III

ANALYSIS OF COVARIANCE OF DATA FOR
BASS TEST OF DYNAMIC BALANCE

Component of Variability	SS	df	V	F	F_c
Treatment	598.621	1	598.621	4.40*	4.26
Error	3265.312	24	136.055		
Total	3863.933	25			

*Null hypothesis rejected at 5% level of significance.

TABLE IV

TESTS OF NONADDITIVITY FOR BASS TEST OF DYNAMIC BALANCE

	F	F_c
Sample Variances	9.282*	3.09
Sample Regressions	10.142*	4.28

*Null hypothesis rejected at 5% level of significance.

TABLE V

ADJUSTMENT OF SAMPLE MEANS FOR
BASS TEST OF DYNAMIC BALANCE

	N	M_x	M_y	$M_{xy(adjusted)}$
Control	12	60.167	75.917	79.133
Experimental	15	70.467	91.000	88.386*
Totals	27	65.889	84.296	

*Indicates the group which showed the greater improvement.

TABLE VI

ANALYSIS OF COVARIANCE OF DATA FOR SIDEWARD LEAP TEST

Component of Variability	SS	df	V	F	F_c
Treatment	.621	1	.621	.013	4.26
Error	1159.946	24	48.331		
Total	1160.566	25			

that the differences between the groups were not significant; in other words, one condition did not appear to be superior to the other condition in regard to performance on the Sideward Leap Test. The results of the tests of nonadditivity of the sample variances and the sample regressions are shown in Table VII. Both tests could be accepted which signified that the treatment effects were constant and additive and the sample regressions were not significantly different.

Comparisons Within Each Group

Fisher's "t" test of significance of difference between means for small correlated groups was used to compare performance within each group on the two administrations of the Bass Test of Dynamic Balance and the Sideward Leap Test as well as bowling performance. Again, the five per cent level of signifiance was selected as the criterion value for rejecting the null hypothesis. As is evident from the data presented in Table VIII and Table IX, both experimental and control groups showed significant improvement on all three measures.

II. INTERPRETATION OF DATA

Greenlee (60) concluded that there is a low, but positive, relationship between dynamic balance and bowling performance. It would appear to this investigator on the basis of the Greenlee results that training for one might result in some improvement in the other. However, such an assumption was not supported by the present investigation.

TABLE VII

TESTS OF NONADDITIVITY FOR SIDEWARD LEAP TEST

	F	F_c
Sample Variances	1.083	3.36
Sample Regressions	.105	4.28

TABLE VIII

FISHER'S "t" TEST OF SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF BOWLING SCORES FOR BOTH THE EXPERIMENTAL AND CONTROL GROUPS

Tests	N	R	Mean	SD	t
Control group					
Pre-test	12	328-541	429.083	58.470	
					3.317*
Post-test	12	363-683	502.083	90.594	
Experimental group					
Pre-test	15	353-491	441.8	46.381	
					4.656**
Post-test	15	357-615	509.4	55.983	

*t = 2.201 at 5% level of significance.
**t = 2.145 at 5% level of significance.

TABLE IX

FISHER'S "t" TEST OF SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS ON BALANCE TESTS FOR BOTH THE EXPERIMENTAL AND CONTROL GROUPS

Tests	N	R	Mean	SD	t
Bass Test of Dynamic Balance					
Control group					
Pre-test	12	26-97	60.167	23.333	4.046*
Post-test	12	23-98	75.917	21.604	
Experimental group					
Pre-test	15	28-96	70.467	18.413	3.741**
Post-test	15	76-100	91.000	7.155	
Sideward Leap Test					
Control group					
Pre-test	12	12.4-45.5	30.808	10.698	4.723*
Post-test	12	20.3-52.5	41.275	10.521	
Experimental group					
Pre-test	15	18.0-50.6	33.06	10.910	5.769**
Post-test	15	23.9-60.0	43.04	10.697	

*t = 2.201 at 5% level of significance.
**t = 2.145 at 5% level of significance.

Results reported in Table I indicated that there was no significant difference between the experimental and control groups in bowling performance. This similarity of groups in bowling performance might be attributed to the method of instruction which was the same for both groups. As there was no difference, it appears that the balance training had no significant effect on bowling performance. The time the balance training program was held might have accounted for this lack of difference. If the fifteen minute balance program held prior to bowling classes for the experimental group induced appreciable fatigue, this factor might be responsible for the lack of difference.

Scott and French have stated, "Experience has shown that excessive fatigue, particularly long-term chronic fatigue, reduces balance control." (23:320) On the basis of this statement, it would appear that the pre-bowling balance sessions might possibly have had adverse effects on bowling performance. As balance appears to play an important role in effective bowling (11, 19, 44), it would seem that if training for balance prior to participation in bowling in any way induced fatigue, bowling performance might consequently be affected.

The data presented in Table III indicated that there was a significant difference between the experimental and control groups in performance on the Bass Test of Dynamic Balance. As an attempt was made to keep all other conditions constant, it was hypothesized that the difference can be attributed to the balance training. Results reported in Table IV indicated that the experimental group showed the greater improvement. These results supported the findings of Garrison (58), who concluded that dynamic balance of college women can be improved by teaching balance exercises.

Results reported in Table VI indicated that the differences between groups were not significant for the Sideward Leap Test. These data can be interpreted as indicating that neither condition was superior to the other.

With the Bass Test of Dynamic Balance there was a significant difference between the two groups; with the Sideward Leap Test the groups were not significantly different. The author suggests that the two tests might be measuring different aspects of dynamic balance. This opinion is strengthened by a relatively low correlation (r = .582), although significant, which existed between the pre-test scores on the dynamic balance tests.

The results of the test of significance of mean differences within groups indicated that both groups improved significantly in dynamic balance and bowling performance. The improvement in balance ability might have been due to practice effects during the initial testing, a desire to improve, or the understanding and confidence gained from having previously taken the balance tests. The actual cause of the increase is not known. The significant improvement in bowling performance might be attributed to class instruction.

The results of this study indicated that bowling performance at the beginning level was not affected by training for dynamic balance. The effects of training for dynamic balance need to be investigated further to determine if varying aspects of dynamic balance exist and if they do exist, to what extent.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the effect of training for dynamic balance on bowling performance. A secondary purpose was to determine the effect of training for dynamic balance on balance performance.

Twenty-seven women enrolled in four bowling classes at the University of North Carolina at Greensboro served as subjects for this study. The experimental group of fifteen subjects received training for dynamic balance in addition to regular bowling instruction; the control group of twelve subjects received only bowling instruction. A total of twenty-seven subjects completed the study.

The four bowling classes were taught by the author and received the same instruction. The method of instruction stressed spot bowling using the four step approach and the straight ball delivery. Classes met twice a week for seventeen weeks.

The subjects were measured on dynamic balance and bowling performance. The Bass Test of Dynamic Balance and the Sideward Leap Test were used as measures of dynamic balance. The totals of the first and last five lines were used as measures of bowling performance on the pre-test and post-test, respectively. The testing in dynamic balance was conducted after five lines of bowling had been completed, and again after a total of twenty-one lines had been bowled.

The covariance design was used to determine the effect of training for dynamic balance on bowling performance and the effect of training for dynamic balance on balance performance. The only result found statistically significant was obtained on the Bass Test of Dynamic Balance. This significant F was in favor of the experimental group.

Fisher's "t" test of significance of difference between means for small correlated groups was used to determine if any significant difference existed within groups in regard to bowling and dynamic balance. Each group improved significantly in bowling performance, the Bass Test of Dynamic Balance, and the Sideward Leap Test.

Within the limitations of this study, the following conclusions were made:

1. Bowling performance at the beginning level was not improved significantly by a training program in dynamic balance.
2. Training for dynamic balance improved balance performance on the Bass Test of Dynamic Balance.
3. Training for dynamic balance did not improve balance performance on the Sideward Leap Test.

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APPENDIX A

BASS TEST OF DYNAMIC BALANCE (29)

Administrators:

1. The instructor explains the test and silently counts the number of errors during performance.

2. The timer, using a stopwatch, counts each five seconds aloud. The count begins with "one" as the performer leaps into each circle.

Equipment and Facilities:

1. Stopwatch, pencil, and score card.

2. The pattern for the test is painted on the floor according to directions Bass has given. (See page 60)

Directions to the Subjects:

1. Stand on the right foot in the circle marked X. This is the starting circle.

2. Leap on the left foot into the circle marked 1.

3. The following count as errors:

    a. Lowering the heel to the floor.

    b. Touching the boundary lines of the circles.

    c. Sliding or wiggling the foot along the floor in an attempt to keep the balance.

    d. Hopping on the foot in the circle. (Error for each hop)

    e. Touching the floor outside the circle.

    f. Touching the other foot to the floor.

    g. Touching the floor with any other part of the body.

4. Remain in each circle for five seconds in a stationary position.

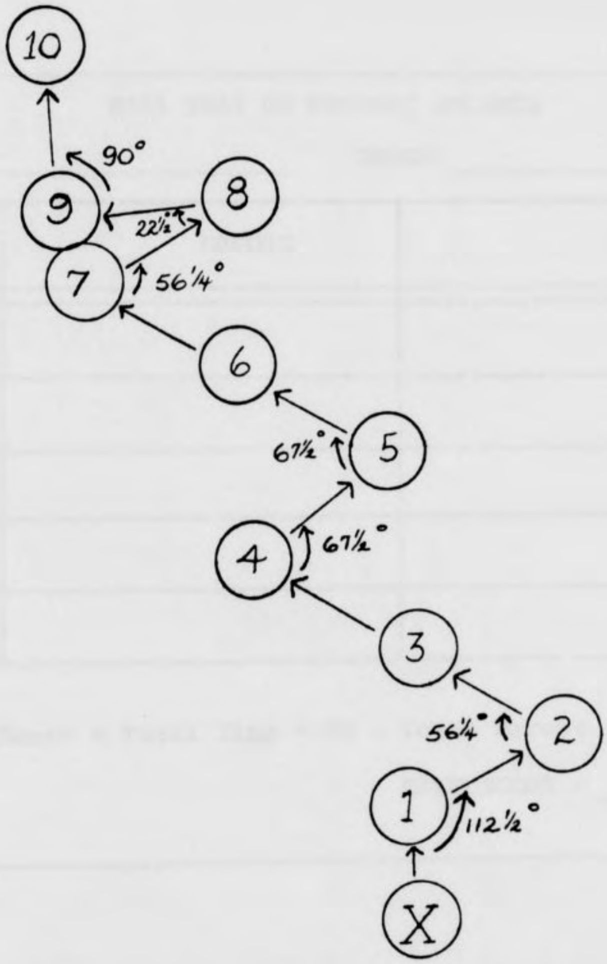
5. Continue leaping into the remaining circles, observing the instructions as given for circle one. Remember that the greater the time spent in each circle, and the fewer the errors, the better the final score.

Scoring

1. After three practice trials, the better of the next two trials is scored. This may be thought of as giving the subject five trials and then taking the best of the five for scoring.

2. The final score is the total "time" plus fifty minus three times the total errors. (Each error counts one penalty point.)

DIAGRAM OF BASS TEST OF DYNAMIC BALANCE



Circles, 8½ inches in diameter, are drawn on the floor.

X is the starting circle

Distance from X to circle 1 is 18 inches

Distance between other circles is 33 inches.

SCORE CARD FOR BASS TEST OF DYNAMIC BALANCE

BASS TEST OF DYNAMIC BALANCE

NAME:______________________ GROUP:______________________

TRIAL	ERRORS	TIME
1		
2		
3		
4		
5		

Final Score = Total Time + 50 - Total Errors

BEST SCORE = __________

APPENDIX B

SIDEWARD LEAP TEST (23)

Administrators:

The administrator explains and demonstrates the test, measures the subject's leg from hip joint to the floor, and times and scores the test.

Equipment:

A stopwatch, cork, yardstick, and score card are needed to administer the test. The pattern for the test is painted on the floor according to directions Scott and French have given. (See page 65)

Directions to the Subjects:

Place your left foot on this square (indicate proper square). You will leap sideward, landing on your right foot so that your foot completely covers this circle (indicate circle A) and immediately lean forward and knock the cork off its circle and hold this position for five seconds. You will have three trials on the right foot, three on the left foot and then will repeat the trials on each foot for a total of twelve trials. It is a failure if you fail to completely cover the circle with your foot when you land, move your foot after landing on the circle, fail to bend down immediately and knock the cork off, rest the hand on the floor, or fall down. Remember to hold your balance for five seconds. You will be told when five seconds is up.

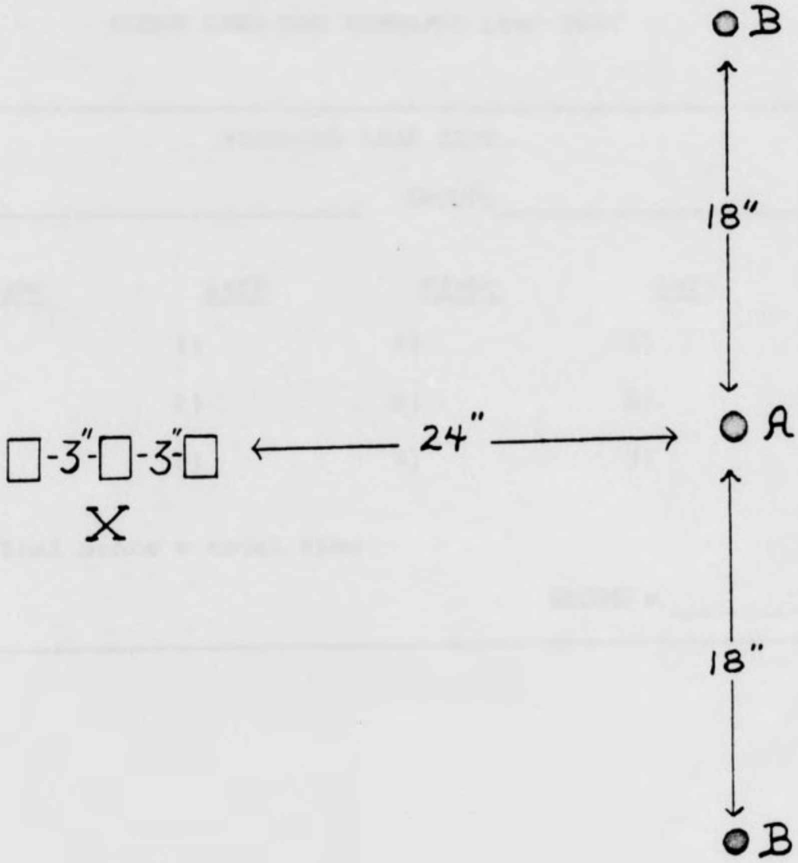
Description:

The pattern is constructed by painting three one-inch circles in a straight line eighteen inches apart. The center circle will be labeled circle A. The outer circles are labeled as circles B. On a line at right angles to the previous line extending out from circle A, place three one-inch squares. The squares should be three inches apart and from thirty-two to forty inches from circle A, depending on the height of the subjects. Measure the length of the subject's leg from trochanter to the floor. For the starting point, select the square whose distance from circle A corresponds most nearly with the subject's leg length. The cork is placed on circle B. (The base of a badminton shuttlecock was used in place of a cork.) The five seconds begins when the subject taps the cork.

Scoring

The score is the total time the balance is held for the twelve trials. A perfect score is 60. No credit was given if the balance was held for less than .5 seconds.

DIAGRAM OF SIDEWARD LEAP TEST



X = starting point.

A = point of landing on sideward leap.

B = point for finger contact, upper B for leap to right, lower B for leap to left.

SCORE CARD FOR SIDEWARD LEAP TEST

SIDEWARD LEAP TEST

NAME: ____________________ GROUP: ____________________

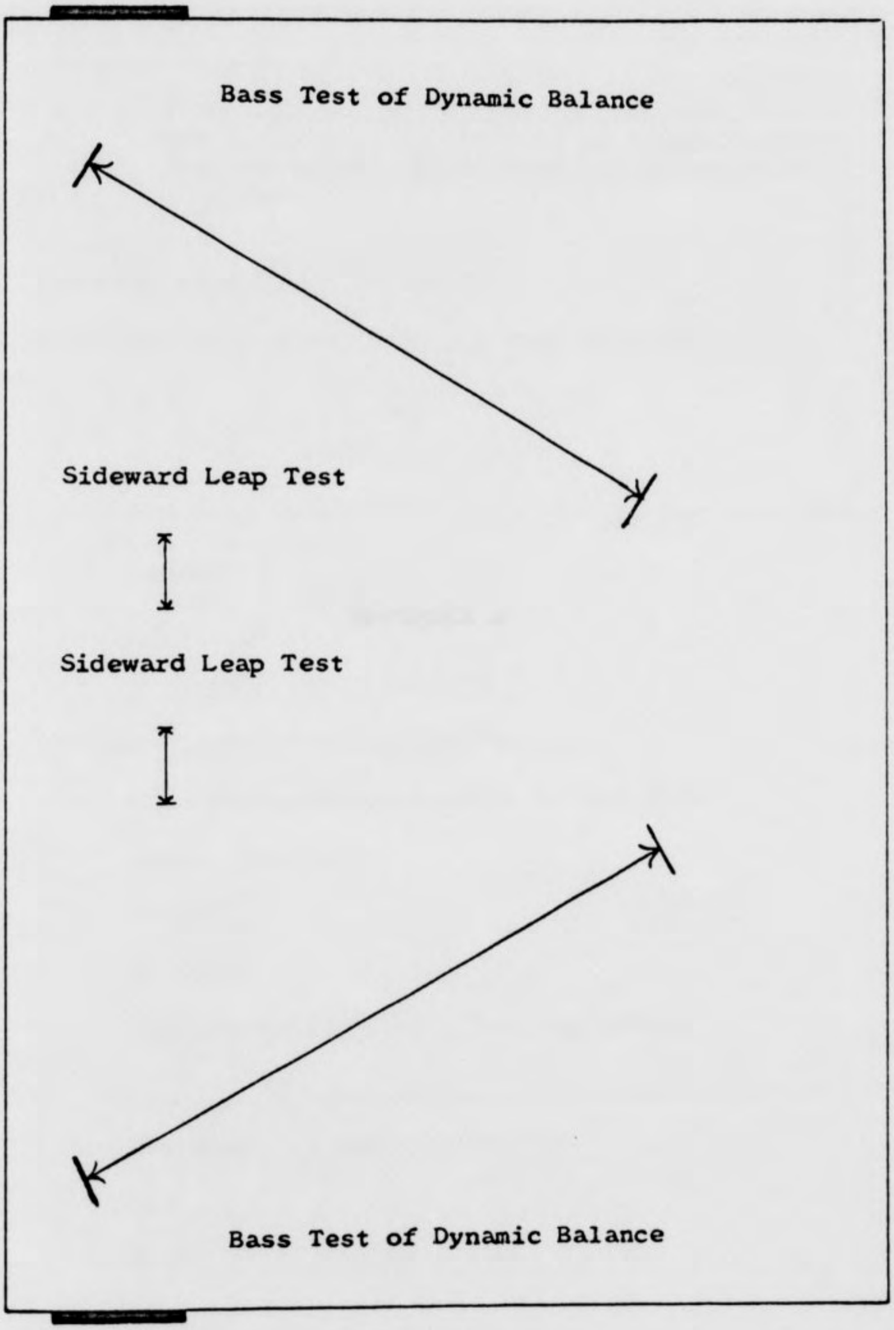
Right	Left	Right	Left
1)	1)	1)	1)
2)	2)	2)	2)
3)	3)	3)	3)

Final Score = total time

SCORE = ________

APPENDIX C

DIAGRAM OF TEST ORGANIZATION



APPENDIX D

QUESTIONNAIRE TO IDENTIFY BEGINNING BOWLERS

Name ______________________________ Section __________

Date _______________

Directions: Please answer the following questions by circling one response. If there is no response which applies to you, write your own in the space provided.

I. Previous experience in bowling:

A. How many games have you ever bowled?

none 1 2 3 4 5 6 7 8

9 10 more than 10

B. How many games have you bowled in the last three years?

none 1 2 3 4 5 6 7 8

9 10 more than 10

II. Previous instruction in bowling:

A. From whom did you receive instruction?

School teacher

Friend

Parents

Representative from a bowling alley

____

B. How many lessons did you have?

1-5

6-10

11-15

____

C. Where did these lessons occur?

School situation

Public bowling alley

____

III. If you know your average, indicate it here and the number of games on which it is based.

____

APPENDIX E

INFORMATION PRESENTED TO EXPERIMENTAL SUBJECTS CONCERNING PARTICIPATION IN THIS STUDY

As beginning bowlers in this class, you have been selected to participate in a study this semester which represents partial fulfillment of the requirement for the degree of Master of Science in Physical Education. This study concerns the effect that training for balance has upon bowling performance.

For approximately eight weeks you will be asked to come to class fifteen minutes early to participate in a balance training program. Your regular thirty minute bowling class will follow the balance sessions.

At the beginning and conclusion of the balance training program, you will be asked to participate in two activities which will measure your ability in dynamic balance. Each session will be conducted at night and will require approximately thirty minutes of your time. Every effort will be made to schedule sessions at your convenience.

It is hoped that you will be able to participate in this research project; your cooperation will be greatly appreciated. Please let me know before you leave class today whether or not you will be willing to participate. If you have any questions regarding participation in this study, they may be asked now.

INFORMATION PRESENTED TO CONTROL SUBJECTS CONCERNING PARTICIPATION IN THIS STUDY

As beginning bowlers in this class, you have been selected to participate in a study this semester which represents partial fulfillment of the requirement for the degree of Master of Science in Physical Education. The study concerns balance in regard to bowling performance.

After the completion of five games in bowling and again toward the latter part of the semester, you will be asked to participate in two activities which will measure your ability in dynamic balance. Each session will be conducted at night and will require approximately thirty minutes of your time. Every effort will be made to schedule sessions at your convenience.

It is hoped that you will be able to participate in this research project; your cooperation will be greatly appreciated. Please let me know before you leave class today whether or not you will be willing to participate. If you have any questions regarding participation in this study, they may be asked now.

APPENDIX F

BALANCE LESSON PLANS

Lesson I

Introduction:

As beginning bowlers in your class, you have been selected to participate in a study dealing with the effects of training for balance on bowling performance. We will be working on balance training twice a week for approximately fifteen minutes each session. This fifteen minute session will precede your regular bowling class for nine weeks or eighteen sessions. The things on which we will be working should be applicable to your bowling.

We will be trying to improve balance by understanding the principles of balance, applying these principles in exercises, and practicing these exercises. These exercises will range from elementary to complex and will consider balance in position, in motion, and in recapturing balance after being in the air.

After some of these exercises have been practiced on the floor, we will try them on the low balance beam. On the balance beam we will be concerned with walks, runs, slides, jumps and leaps, movements to the left and right, changes of positions, movements in high posture, movements in low posture, and changes of your base. As performance on a high apparatus has the added ingredient of fear, we will start all movements on the floor and then progress to the low balance beam. When working on the beam, spotters will always be used as a safety precaution.

Balance

What is balance? How would you define it? (Have one of the students respond.) Balance is the ability to assume and maintain any body position against the force of gravity. What is the force of gravity? Maintenance of balance involves a delicate interplay of muscles working to keep the body over the base. Balance is made possible by the equilibrium center in the brain and the neuromuscular processes which transmit the proper orders to the proper muscles during activity.

Practice:

1. Walk the length of the balance beam.* I will stand here to help you if you lose your balance.

2. Walk the length of the beam raising your knees waist high with each step.

3. Choose a partner and try to walk a straight line on the floor with your eyes closed. Your partner will help you if you go too far out of line.

During your attempt to walk a straight line, did you find that you could not do so with your eyes closed? Your eyes play a very important part in balancing.

During the next session we will discuss some of the principles involved in balance.

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*Construction of beam patterned after that of McDaniel.

(59)

Lesson II

Introduction:

We have said that balance is the ability to assume and maintain any body position against the force of gravity. In the standing position assume what you consider a balanced position. Now lean forward without bending your knees. Where is your weight now? Your weight is still on your feet, but it has shifted forward to the balls of your feet. Now lean backward. Where is your weight now? It is on your heels. Now try to find the position midway between these two extremes in which you feel that you are balanced.*

In considering balance, we must take into account the center of gravity which is the weight center of the body. In women the center of gravity is usually located at the pelvic girdle since approximately half of the body weight is above the hip joint and half below. Place your hands on your sides just above the hip joint; this is approximately the height of your center of gravity. The line of gravity is the vertical line which falls through the center of the body. Therefore, you can approximately locate your center of gravity at the point at which a transverse line running across the top of the hips intersects the line of gravity.

The nearer to the center of gravity that the line of gravity falls, the more stable the base. Conversely, the nearer the line of gravity to the edge of the base, the more

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*Adapted from Garrison. (58)

precarious is the equilibrium. Stand with your feet slightly apart, with the weight evenly distributed over both feet, and have your partner push toward the right against your left shoulder. Now, stand with the weight on the right foot, and ask your partner to push against your left shoulder. Notice that balance is more easily maintained when you start with your weight in the center of your stance; this is true because your center of gravity has a greater range of movement before falling beyond the edge of your base, or beyond the side of the right foot.

Practice:

Focusing your eyes on the opposite end of the beam from which you start, and using your arms for balance, walk the length of the beam.

Now clasp your hands behind your back and walk the beam. Is it easier to walk the beam with your hands out to your sides or behind your back? Your arms will be quite beneficial to you as you do various movements on the beam, so remember to use them to help you balance.

Let's see if you can do a front scale.

1. Get arms distance apart on the floor. Balance on your right foot, extend your left foot, and place your arms out from your head. Hold this position for five seconds if you possibly can.

2. Now try to do this front scale on the balance beam. Remember to have a partner spot for you as you try this scale.

Lesson III

Review:

During the last session we discussed balance in regard to the line of gravity falling near the center of the base. Facing the wall, stand about two feet away and lean forward until you lose your balance. Catch yourself on the wall. Did you notice that you lost your balance as soon as your center of gravity went beyond the edge of your feet? Remember that equilibrium becomes less stable as the line of gravity nears the edge of the base.

Introduction:

Another principle of balance is that the larger the base, the more stable the body; the center of gravity can move a greater distance without falling outside the base. Stand with the feet together and have your partner push against your left shoulder. Now place the feet in a side-stride position and have the partner push against the left shoulder. In which position is balance more easily maintained? Now stand with your feet together and have your partner push against your shoulders from behind. Now place the feet in a forward-stride position and have the partner push against your shoulders from behind. In which position is balance more easily maintained? In the first situation the side-stride position was the better and in the latter situation the forward-stride position was better because the base is wider in these directions, and the center of gravity has more opportunity to move before falling beyond the edge of the base. It is important to widen the base in the direction of the applied force.

Practice:

Let's see how well you can control your balance in a hand wrestle with your partner.* (Select a partner and demonstrate while explaining.) Grasp right hands and lift your left foot off the floor. Try to push or pull your partner off balance so that she will either move her right foot or touch her left foot to the floor. See who can win two out of three times; then try it on your left foot with left hands grasped.

Stand on the four inch balance beam. Now stand on the two inch beam. On which is it easier to balance and why? It is easier to balance on the four inch beam because it has the larger base of support.

Balance Beam Work:

1. Walk the line on the floor slowly; now walk it faster.

   Walk on the balance beam, first slowly and then faster.

2. Using the line on the floor, touch the toe forward and backward with the left foot; step forward with the left foot. Repeat with the right foot.

   Do the same movement on the balance beam, using the left foot first and then the right.

3. Balance on the floor on the left foot, right leg abducted (sideward).

   Try this movement on the beam.

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*Adapted from Garrison. (58)

4. Walk the line on the floor with lunging steps. Use lunging steps to walk the beam.

(In all exercises which follow, movements to be executed on the balance beam will be preceded by the same drill on the floor.)

Lesson IV

Review:

Last session we discussed the principle that the wider the base of support the more stable the body. Stand on one foot. Now stand on both feet. As you can see, it is much easier to keep your balance when standing on both feet as this provides a wider base of support. There are two points to remember:

1. Balance is maintained when the center of gravity is over the base of support.

2. Balance is more easily maintained when the base of support is large.

Stand on your toes with the feet together and raise your arms directly overhead. Now raise your arms overhead, spread your feet shoulder width apart, and support your weight evenly on both feet. Which of the positions is easier to maintain? It is easier to maintain the latter position as it has a lower center of gravity and a wider base of support. Let's exaggerate this by standing first on your tiptoes with your feet spread a comfortable distance apart. Now lower your heels to the floor, spread the feet a comfortable distance apart, and bend your knees.

The second position should be easier to maintain and more stable because you have lowered your center of gravity by bending your knees and have used a larger base of support.

Practice:

1. Walk on tiptoe along the line on the floor.
2. Hop on one foot along the line on the floor.
3. Skip along the line on the floor.
4. Slide along the line on the floor.
5. Try these four movements on the beam. Have your spotter stand near in case you lose your balance.

Lesson V

Introduction:

Walk along the line on the floor with your knees bent. Now walk along the beam with your knees bent. Walk along the line on the floor with thigh flexion. Now walk the beam with thigh flexion.

The bent knee walk and the walk with thigh flexion were different from your usual method of walking, but do you usually feel balanced as you walk? You should feel balanced during each movement of a slow walk. Try to walk the line on the floor and be aware of your body position. We will also be using the balance beam to improve your balance in walking.

Practice:

1. Walk the straight line of the floor three times.
2. Walk the low balance beam three times.

3. Walk the line on the floor backward three times.

4. Walk the beam backward three times.

5. Advance by a walk-stand alternately on the beam and floor.

6. Throw a ball and catch it while walking the path on the floor.

7. Try to walk the path on the floor with the hands "tied" behind your back.

Lesson VI

Introduction:

When walking the balance beam, you use your left arm to help maintain balance when you get too far to the right. Whenever one part of the body moves away from the line of gravity, the center of gravity shifts in that direction. If this shift puts the center of gravity beyond the base, another body part must move in the opposite direction to bring the center of gravity back over the base or balance will be lost. Balance on the left foot with the right foot extended. Notice how the trunk moves forward to compensate for the backward movement.

Practice:

As we have already said, whenever one part of the body moves away from the line of gravity, the center of gravity shifts in that direction. Let's see how this principle applies in the following balances, first on the floor and then on the beam.

1. Balance on the right foot, left thigh and leg flexed, body arched backward.

2. Balance on the right foot, left thigh and leg flexed; extend the left leg.

3. Do a front scale. Balance on the right foot, extend the left foot, and place your arms out from your head.

4. Do a back scale. Balance on your right foot, flex your left thigh and knee, raise your right arm overhead, and use your left arm for balance.

Lesson VII

Review:

When I blow the whistle, run as fast as you possibly can. On the second blast of the whistle stop immediately with both feet together. When you tried to stop with both feet together, you had to place one foot out in front so that the result was a forward stride position and so that balance could be maintained. We have said before that whenever one part of the body moves away from the line of gravity, the center of gravity shifts in that direction. If this shift puts the center of gravity beyond the base, another body part must move in the opposite direction to bring the center of gravity back over the base or balance will be lost. Balance can be regained without the shift of a body part in the other direction by establishing a new base which is under the shifting center of gravity. When you tried to stop so abruptly, you regained your balance by establishing a new base which was under the center of gravity.

Stand with your back to the wall, heels against the wall, and lean forward. The bending of the upper body shifts the center of gravity beyond the forward edge of the base, and either the body falls forward or one foot is shifted forward to establish a new base.

Practice:

1. Walk the balance beam carrying a heavy book with your arms extended. Notice that you compensate by leaning backward.

2. Stand with both feet together and bend at the waist. Notice that you will put your hands on the floor to keep from falling. In this new position with your weight over your hands and feet, you have established a new base of support.

3. Stand on the beam, one foot forward; slightly bend the knees and jump up, landing in the original position. Lift your arms to the side for better balance.

4. Repeat the same exercise changing the foot position in the air so that you land with the rear foot in front.

5. Skip the length of the beam.

Lesson VIII

Explanation:

During the last session you carried a heavy book with your arms extended. External weights added to the body become part of the total body weight and affect the location of the center of gravity, displacing it in the direction of the added weight. Therefore, the closer the weight is held to the center of gravity, the less it changes the location of the center of gravity and the less effort required to hold it.

Practice:

Let's work on a few stunts involving balance.

1. Stork Stand
   Stand on the left foot. Hold the bottom of the right foot against the inside of the left knee. Place the hands on the hips. Shut both eyes and hold the position for ten seconds without shifting the left foot on the floor.

2. Cross-Leg Squat
   Fold the arms across the chest. Cross the feet and sit down cross-legged. Get up without unfolding the arms or having to move the feet to regain the balance.

3. Full Left Turn
   Stand with the feet together. Jump into the air and make a full turn to the left, landing on the same spot. Do not lose the balance or move the feet after they strike the floor.

4. Half-Turn Jump -- Left Foot
   Stand on the left foot and jump one-half turn to the left, maintaining balance.

5. Full Right Turn
   Stand with both feet together. Swing the arms and jump up in the air, making a full turn to the right. Land on the same spot and do not lose the balance; that is, do not move the feet after they first strike the floor.

Lesson IX

Explanation:

Many sensory organs are important in the maintenance of balance -- the organs of the inner ear, the semicircular canals, the organs of vision, the organs of touch, and the end organs of the kinesthetic sense (the proprioceptors in the muscles, tendons, and joints). You know that you become dizzy when you turn around rapidly. Have you ever heard that a ballet dancer who constantly turns always focuses on a certain spot in order not to become dizzy? Turn around rapidly six times. Do you feel dizzy? Now find a spot on the wall before you start turning; each time you make one complete turn, bring your focus back to that spot. Are you as dizzy when you watch the spot? Stand on one foot with your eyes open and then close them. If you will remember trying to walk a straight line with your eyes closed, you can see how important the eyes are in the maintenance of balance. In general, the focus of the eyes should be in the direction of the intended movement since the body tends to follow the direction of the head. Therefore, in walking the balance beam you should focus ahead toward the end of the beam.

Practice:

1. Walk the balance beam with your eyes focusing directly on your feet.
2. Walk the beam with your eyes focusing on the beam about two feet away from your feet.
3. Focus on the opposite end of the beam and keep your focus there as you walk the beam.

Where was the best point of focus for you?

Review:

1. Hop the length of the beam on one foot.
2. Skip the length of the beam.
3. Perform a front scale.
4. Perform a cross-leg squat.

Lesson X

Review:

Today we will be doing a different type of exercise on the balance beam. Rather than moving forward and backward, we will be doing exercises which involve lateral or sideward movements. Master the exercises on the line on the floor before you attempt them on the beam.

Practice:

Exercises to be performed on the beam:

1. Facing sideways, step sideward with the left foot and close the right foot. Repeat.
2. Stand sideways, place your right foot alternately in front of and behind your left foot.
3. Facing sideways, jump to stride stand and return.
4. Facing sideways, click heels and return to position.

Exercises to be performed only on a line on the floor:

1. Facing sideways, do a jacknife and return to position.
2. Facing sideways, do a half turn alternately left and right.
3. Facing sideways, spin the top. Make a full turn in the air and return to position.

Lesson XI

Review:

Last session we worked on exercises from the sideward position. Some of the exercises were too advanced for some of you. Let's review some of the less complicated exercises.

1. Grapevine

2. Jump to stride stand

3. Click heels

4. Step sideward and close

Explanation:

When we discussed the center of gravity, we considered it as the weight center of the body. The nearer to the center of gravity that the line of gravity falls, the more stable the base. Conversely, the nearer the line of gravity to the edge of the base, the more precarious is the equilibrium.

Practice:

Since we have done little work with hopping and jumping, let's do some exercises involving these two movements. Remember the principles involving the center of gravity as you execute these exercises.

Exercises to be performed on a line of the floor:

1. Hop forward on one foot.

2. Jump forward in walk stand.

3. Hop in place on the left foot, making quarter turns.

4. Hop in place on the right foot, making half turns.

5. Hop, step, and jump to walk stand.

Exercises to be performed on the beam:

1. Hop from the floor to the beam and hold your balance on the beam for five seconds.

2. Straddle the beam and try to jump up on it and hold your balance for five seconds.

Lesson XII

Demonstration and Explanation:

We have been progressing from elementary to more complex exercises; today we will be practicing even more difficult movements. All of these exercises must be mastered on the line on the floor before you attempt them on the beam. Spot carefully. Remember the principles we have discussed and try to apply them to each situation.

1. Pirouette
   Facing sideways, do a half turn left on the right foot, half turn right on the left foot. Repeat continuously.

2. Advance, hopping on one foot from the balance beam to the floor.

3. Side-stand alternately on the beam and the floor.

4. Advance, alternately straddling the beam and walk standing.

Those of you who are having difficulty with these exercises should continue to work on them. Those students who have mastered these exercises may work on the following exercises:

1. Straddle the beam, half turn to walk-stand on the beam.

2. Straddle the beam, full turn to straddle the beam.

Assignment:

Be thinking about some low movement that you can do on the beam; the movement may be either fast or slow. It may be some exercise we have done during these sessions or it may be one you have devised.

When you come to the next session, bring a list of the exercises which were the most difficult for you to perform.

Lesson XIII

Explanation:

At the end of the last session we mentioned your choosing some movement that you can perform on the beam. The only qualification was that the movement be low. Spend the next two or three minutes thinking about your movement and practicing it. After that time, we will see what you have selected. Your movement may be as simple or as difficult as you wish; just be sure you can perform it adequately and that you have a spotter. (Students perform movements.)

Review:

We have worked with quite a few exercises. Have you been able to perform each one of them well? Let's review a few of the exercises on the beam.

1. Hop the length of the beam on one foot.
2. Perform a half-turn jump on the left foot.
3. Execute a full right turn.
4. Facing sideways, click the heels and return to your original position.

(Collect the lists of exercises. Whenever time permits at the end of the remaining sessions, work will be done on these exercises.)

Assignment:

For the next session please be thinking about a high movement which you can perform on the beam. Your movement may be one that we have done in class or it may be one that you have devised.

Lesson XIV

Explanation:

At the end of the last session we discussed your choosing some movement that you can perform on the balance beam. The only qualification was that the movement had to be high. Spend two or three minutes thinking about your movement and practicing it. After that time, we will let each girl perform on the beam. Your movement may be as simple or as difficult as you wish; just be sure that you can perform it adequately and that you have a spotter. (Students perform movements.)

Review and Practice:

Let's review a few of the exercises on the beam.

1. Balance on the left foot, right foot extended.
2. Walk the length of the beam at a fast pace.
3. Balance on the right foot, left thigh and leg flexed; extend the left leg backward.
4. Front Scale
   Balance on your right foot, extend your left foot, and place your arms out from your head. Hold this position for five seconds.
5. Back Scale
   Balance on your right leg, flex your left thigh and knee, raise your right arm overhead, and use your left arm for balance.

Assignment:

For the next session be thinking about combining two movements on the beam. These may be any of the exercises we have done in class or ones that you have devised. Plan to perform one exercise and then move on the beam to perform the other exercise.

Lesson XV

Explanation:

At the end of the last session we discussed your choosing two exercises to be performed on the beam. The only requirement was that after the first exercise you move to perform the second exercise. Spend three or four minutes thinking about your combination of movements and practicing them. After that time, we will let each girl perform. Your movement may be as simple or as difficult as you wish; be sure you have a spotter as you perform. (Students perform movements.)

Review:

Review of the exercises on which the girls wish to work.

Lesson XVI

Explanation:

For the past few sessions you have been doing exercises of your own choosing on the beam. Today let's see how well you can combine a series of these movements to fit a jingle. Your instructions are to do as follows:

Something fast, something slow;
Something high, something low

Work individually, and at the end of five minutes we will see what you have chosen.

Lesson XVII

Explanation:

We will use our time today in reviewing the exercises which you have listed as most difficult.

Lesson XVIII

Review:

We have discussed principles of balance and have applied these principles in various exercises. Hopefully, these exercises have been meaningful for you. You should have been able to apply the things we have discussed to bowling as well as to your everyday activities. The center of gravity, the size of the base of support, the addition of external weights, the establishment of a new base of support, the use of the arms for balance -- all of these are important to you each day.

Statement of Appreciation:

BALANCE BEAM (59)

Length: approximately 16 feet

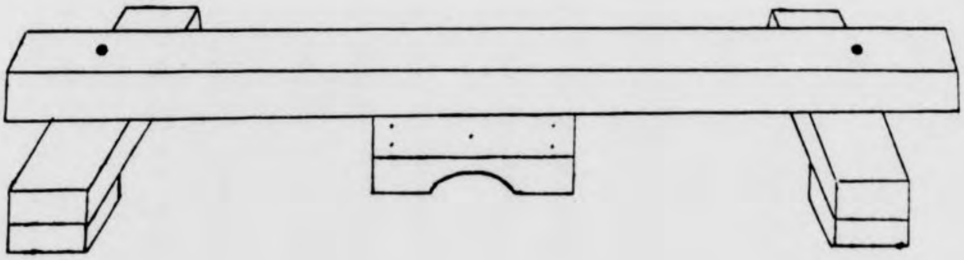
Width: 4 inch walking surface

Material: 4 x 4 inch beam of fir or other wood that will not warp
4 feet 4 x 4 for cross pieces
2 bolts, ½ x 8 inches, with nuts
short pieces of 2 x 4

End Bases: (cross pieces) approximately 21 inches long
These are made of 4 x 4 with 2 x 4 nailed to it at each end.
Attached to the beam at about 11 inches from each end, by a bolt and nut, the head of the bolt countersunk so that it does not interfere with the smooth walking surface of the beam.
By attaching the bases in this manner, they are movable and may be turned underneath the beam for easier storage.

Center Base: a 4 x 4 nailed to a 2 x 4, nailed to the center of the beam, not movable.

Height from walking surface to the floor is 9 to 10 inches.



APPENDIX G

TABLE X

CORRELATION COEFFICIENTS

X	Y	r
Average of first five games	Average of last five games	.653
Average of first five games	Average of first three of last five games	.568
Average of first three games	Average of last five games	.527
Average of first five games	Average of last three games	.486
Average of first three games	Average of first three of last five games	.476
Average of first three games	Average of last three games	.466
Bass Test of Dynamic Balance	Sideward Leap Test	.582

APPENDIX H

TABLE XI

RAW DATA

SUBJECT	BASS TEST OF DYNAMIC BALANCE PRE-TEST	BASS TEST OF DYNAMIC BALANCE POST-TEST	SIDEWARD LEAP TEST PRE-TEST	SIDEWARD LEAP TEST POST-TEST	BOWLING PERFORMANCE PRE-TEST	BOWLING PERFORMANCE POST-TEST
Experimental						
1	61	94	20.0	32.5	382	357
2	73	80	31.9	44.5	364	571
3	81	93	46.5	49.0	479	615
4	83	97	43.8	41.0	454	514
5	96	92	27.0	40.0	407	458
6	85	97	32.0	34.5	478	515
7	48	85	21.5	30.3	488	515
8	96	100	43.0	57.2	353	477
9	71	76	21.5	30.3	405	503
10	28	81	18.0	23.9	471	564
11	50	98	42.8	60.0	491	517
12	57	87	45.8	52.8	425	472
13	65	94	23.0	33.7	476	512
14	78	94	28.5	52.6	475	520
15	85	97	50.6	60.0	479	531

TABLE XI

(continued)

SUBJECT	BASS TEST OF DYNAMIC BALANCE		SIDEWARD LEAP TEST		BOWLING PERFORMANCE	
	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST
Control						
16	36	23	20.6	28.2	541	644
17	26	56	12.4	20.3	398	435
18	77	93	35.5	51.8	352	483
19	85	97	44.5	44.5	454	440
20	53	68	43.6	51.9	416	485
21	31	59	19.7	33.7	446	447
22	39	68	20.2	28.9	328	455
23	97	94	45.5	49.7	439	610
24	52	74	35.5	40.5	442	363
25	68	88	24.1	52.5	437	496
26	92	98	31.1	49.6	516	683
27	66	93	37.0	43.7	380	484