RELATIONSHIPS OF BALANCE TESTS TO OLYMPIC
BALANCE BEAM PERFORMANCE

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RELATIONSHIPS OF BALANCE TESTS TO OLYMPIC BALANCE BEAM PERFORMANCE

THESIS

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By

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CHAPTER I

INTRODUCTION

The identification of motor components has become a useful tool in many of the research fields. Physiologists as well as medical researchers have endeavored to discover the element or elements responsible for ineffective motor performance among atypical individuals. Anthropologists and historians have found motor tasks important in the study of the cultures and evolution of man. Perhaps because motor activity is his primary concern, the physical educator has found a comprehensive understanding of motor task components to be an essential undertaking.

It is imperative that the physical educator be able to identify and isolate pertinent motor components in order that instructional aid be offered to those possessing skill difficulty or deficiency. A more comprehensive understanding of motor performance often suggests alternative teaching designs; thus, new improved methods have evolved, promoting quicker success for both student and instructor.

Not only has this concentrated attention to motor task components aided in teaching slow learners, but it
has also been somewhat responsible for the more refined performance of those possessing a higher level of skill. Talented participants are thus enabled to surpass previously recognized sports' records. Too, the study of motor task components makes possible the screening of potential champions. Through the administration of selected motor skills tests, the prediction of potential skill performance has often been attempted. Such an undertaking was conducted by Wettstone (7), who sought to predict potential gymnastic and tumbling ability.

Gymnastics, a sport recognized for its value in the physical education curricula, has been the source for many other analytic studies. Recently, research involving physical fitness has indicated that gymnastics contributes greatly to the physical development of the individual. The activities of this sport fundamentally involve large muscle movements and develop greatly the muscle groups of the arms, shoulders, chest and abdomen; areas often neglected in other sports. Hence, the reinstallation of strong gymnastic programs in the schools has been encouraged.

Accompanying the trend to revitalize gymnastics in the public school physical education program for fitness purposes, is the value of accommodation this activity provides. Often the situation in public schools is that
of large class numbers and little physical space. Due to the nature of gymnastics, many students are able to perform simultaneously and little room is required.

Another reason gymnastics has received additional attention from researchers in terms of study and analysis is the interest in and concern for the United States Gymnastic Team in international competition. Not since the 1904 Olympic Games has the United States fielded a championship team in gymnastics; and, not since 1932 has America produced an Olympic winner in the sport of gymnastics. An effort to correct the unsatisfactory performance of the American team has stimulated the examination of stunt patterns, and the analysis of the motor components involved. Through the use of instant replay tapes, cinematographic films and photographs various movements are better understood and/or improved. Such was the aim of Richard Spencer (6), who used photography to analyze the motor tasks relevant to the performance of the mat kip. Various motor tests administered also help determine important skill components of gymnastic events.

A basic unit of equipment in the girls' gymnastics program is the balance beam. The beam is one of four international competitive events for women. Selected for competition because it aptly displays feminine
physical beauty and skill, the beam has grown in prominence along with the increasing popularity and current revitalization of gymnastics.

Exercises on the beam demand disciplined, conscious control of all parts of the body. While movements should be lively, the speed in performing formal exercises is an individual choice, and depends greatly on the basic rhythm of the performer. Execution is continuous on the beam; monotony of rhythm is avoided, as is the exaggerated duration of sustained positions.

Not only for its encouragement of poise and grace is the balance beam included in the girls' activity programs, but also for its low cost, minimum use of space, and the versatility of stunts involved. Mass method of instruction can begin on the floor using lines, or on bleachers using the planks. Later, activities graduate to low balance beams which are inexpensively made and easily assembled. Eventually the high beam is incorporated into the instructional program. Low beams are also used in the elementary school programs. Simple routines can be created to assure a successful experience for all.

Several motor task components have been determined as factors necessary for balance beam activities. Researchers, coaches and teachers indicate coordination,
strength, flexibility and balance to be among these pertinent components. Cratty (1, p. 49) defines coordination as "the monitoring of neural impulses involved in muscular contraction controlling a rather direct simple movement, as a horizontal arm swing." He further reports another frame of reference: "coordination is construed to be a series of movements of varying speeds and force combining into a motor act of a more complex nature." Because balance beam activities range from the simplest to very complicated motor patterns, both ideas of coordination seem relevant to balance beam performance.

Muscular force or the strength task is also a variable that may effect balance. Guilford (3, p. 165) reveals that strength lies within three broad areas designated as dynamic, explosive and static. These strength qualities as well as another strength factor, trunk strength, are important influences in total execution of balance beam stunts. Flexibility is another overt component of beam tasks. Fleishman, Thomas and Munroe (3) discovered two qualities of flexibility that they termed "dynamic" and "extent," both of which seem to be influential components of gross action patterns on the beam.

Still another component of balance beam performance is gross body equilibrium; one might identify this as the most
important factor. As a function related to physical performance, balance is reported to consist of numerous intrinsic factors. For this reason, investigators have concluded that no test purporting to measure balance can be used for appraising general balance ability. Using various tools to measure and interpret the complexities of this parameter, two broad types of balance have been differentiated: static balance and dynamic balance. Both qualities are involved in performance on the balance beam. Each time a performer pauses for a "pose" or comes to a stop for a "hold," static balance is implicated. Each time the participant actively moves from one end of the beam to the other, dynamic balance is enacted.

The literature describes various tests of balance based on these two classifications. Among the types of tests devised are stunt-type using no equipment, rail or beam walking, and electric balance apparatus tests. It is of interest to this study that little, if any, testing has been conducted regarding the prediction of balance beam performance via balance tests.

Finally, it is not enough to consider only the motor components of balance and Olympic beam performance; another variable to be considered is that of emotional motivation. Cratty (1, p. 39) maintains that a certain level of anxiety
must be present in motor task performance, as anxiety is broadly defined as alertness. However, performance problems are produced if the anxiety arousal is too great. Performing stunt patterns on a plank, three feet and eleven inches from the floor, as in the case of routines executed on the Olympic Balance Beam, may be an example of an extreme arousal of anxiety. This study does not seek to purport fear, anxiety or courage, still height can not be ignored as a variable in the balance test performance.

In an effort to provide more information concerning the role that balance may play in the Olympic Balance Beam event, this study explored the relationships of balance tests to each other and to Olympic Balance Beam skills. In order to accomplish the purpose of this study, answers to the following questions were sought.

1. Is there one balance test that may be used to measure all aspects of balance?

2. Does previous balance beam experience affect balance appraisal?

3. Does increased task height appreciably affect a subject's test performances?

4. Is there a balance test or a combination of these tests that can significantly predict Olympic Balance Beam performance?
Statement of Problem

The major problem of this study was to determine the relationships of standardized balance tests and modified balance tests as predictors of performance on the Olympic Balance Beam. Particularly of interest were the potential performance discrepancies between the standardized Bass Stick Test, the Sideward Leap Test, and these identical tests raised to the height of the Olympic Balance Beam.

Purposes

This study sought to identify a balance test or combination of tests that would efficiently predict Olympic Balance Beam performance. Of interest, too, was the effect previous experience might have on the performance of standardized and modified balance tests. In order to determine if height affected balance performance and would therefore be an element to consider in teaching methods and progressions, the Bass Stick Test and Sideward Leap Test were raised to a height of three feet and eleven inches. Relationship among the balance tests and beam tests were also studied.

Hypotheses

Null hypotheses that were established for this study were

1. No correlation would exist among standardized balance tests, modified balance tests, and performance on the Olympic Balance Beam.
2. People with previous experience on the Olympic Beam would not perform significantly different on balance tests from those possessing no previous balance beam experience.

3. There would be no significant difference in the means obtained from performance on the modified balance test and the means obtained from performances on the standardized test.

4. There would be no balance test or combination of tests capable of significantly predicting Olympic Balance Beam performance.

Limitations

A limitation of this study was the non-random selection of the subjects. Subjects were chosen from those women students selecting a beginning or intermediate gymnastics physical education course at North Texas State University during the spring semester, 1967. From the students enrolled in a beginner's class, only those possessing no previous experience on the Olympic Balance Beam were qualified for the testing program. Amount of experience of intermediates varied, in that they had different teachers and different lengths of time of previous experience. This study utilized the services of four test administrators.
Definition of Terms

Because the literature offered various authorities' interpretations of terms, the following definitions were used in this study:

**Discrepancy score.**—That score computed by subtracting the modified test score from the standardized test score, and used to indicate a potential effect that task-height had on balance performance.

**Dynamic balance.**—Physically, the situation in which the weight is so distributed that the resultant of the forces is varying from moment to moment. Neuromuscularly, the maintenance of an organized postural orientation under conditions in which the activity pattern of the muscles is continually changing so as to disturb the gross postural orientation and require further muscular activity to re-establish the orientation. Psychologically, the posture of the body when the organism is engaged in a specified motor activity which involves relatively large motions of all parts of the body which act to disturb the gross orientation of the organism (5, p. 247).

In this study, dynamic balance is operatively defined as the ability to maintain body control while performing the Sideward Leap Balance Test. This ability was measured in terms of seconds.
**Olympic balance beam.**—A raised, long, narrow wooden plank having the following specifications, according to the Amateur Athletic Union Gymnastic Rule Book (4, p. 113).

<table>
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<th>Specification</th>
<th>Metric Measure</th>
<th>Linear</th>
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<tr>
<td>Length of beam</td>
<td>5 meters</td>
<td>16' 4&quot;</td>
</tr>
<tr>
<td>Width of top surface</td>
<td>10 centimeters</td>
<td>3' 15/16&quot;</td>
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<tr>
<td>Height from floor</td>
<td>120 centimeters</td>
<td>3' 11&quot;</td>
</tr>
<tr>
<td>Thickness of beam</td>
<td>16 centimeters</td>
<td>6 1/2&quot;</td>
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**Static balance.**—Physically, the situation in which the body is acted upon by forces whose resultant is zero. Neuromuscularly, the maintenance of a specified posture in which the antagonistic muscles are so employed that there is a minimum of general body sway or finer muscular movements. Psychologically, the postural orientation of the body when the organism is motivated to remain motionless (5, p. 247).

In this study, static balance was operatively defined in reference to the Bass Stick Test, standardized and modified; it was described as the ability to remain balanced on the stick, in a stationary position with a one foot support. The subject's ability was measured in terms of the number of seconds the balance was successfully maintained.
CHAPTER BIBLIOGRAPHY


CHAPTER II

Review of Literature

The study of equilibrium dates from relatively early investigations that were pursued to meet the needs of a variety of interests. Information regarding aspects of balance has been gleaned from investigations designed to disclose components involved in the function of balance, factors affecting balance, methods to measure balance, as well as the relationships of balance to motor components and sports skills.

Components of Balance

One method utilized by investigators to discover the primary factors of equilibrium has been that of factor analysis. In determining the factors identified by the battery of balance tests of her study and in the function of balance as a whole, Bass (2) discovered several items:

- General eye-motor factor
- General kinesthetic responses or sensitivity factor
- General ampullar sensitivity
- Function of the two vertical semi-circular canals, "tension-giving reinforcement."

In addition, three other factors were found but unnamed and were suggested to be closely allied with muscle tonus. Whelan (36) determined balance factors which he compared to the findings of Bass. His results involved a more detailed
description of the factors, and did not include the "tension-giving reenforcement" factor. His findings did include:

- dynamic balance kinesthetic-response;
- general static balance kinesthetic response
  factor; eye factor functioning in static
  balance, identified as Type I, static balance
  eye factor; Type II, static balance eye factor;
- general ampullar-sensitivity factor; dynamic
  balance eye factor; and, a convergence-of-
  eyes factor.

Additional information concerning components involved in the function of balance has been revealed through the analysis of kinesthesis, and the recognition of balance as a prominent factor in this phenomenon. Scott (30), in an effort to establish a practical and valid method of determining kinesthesis function, discovered balance ability as a specific function of kinesthesis and advocated that a balance test be included in any kinesthesis battery. Bass (2), in an analysis of the components of tests of semi-circular 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 proposed balance tests. Wiebe (38), who also investigated kinesthesis, suggested that balance was among the components ascribed to kinesthesis. He also found that the best combination of tests to measure kinesthesis in college men should include a balance test, specifically, the Balance Lengthwise Test. Others, (4, 12, 27) have subject-
ively suggested a prominent relationship between balance and kinesthesia.

Factors Affecting Balance

Other approaches to the study of equilibrium have involved the investigations of body mechanisms as factors influencing balance. Researchers have discovered physiological, anthropometrical, psychological, and chronological variables to be significant in the stability performances of subjects.

Physiological.—Various functionings of the ear have been investigated for specific information concerning balance. Edwards (10) contends that an essential cause of large sway is "defective vestibular activity." In a later study, Birren (3) found that a stable position could be maintained despite the loss of labyrinth receptors. He concluded, therefore, that measurements of body sway could not be used to detect vestibular defects. White (37), in his study of static ataxia, concurred with Birren. Johnson (21) suggested that visual sensations supplemented, and, in some cases of injury to the vestibular organ, may have substituted for the latter.

The relationships of vision to balance maintenance have provoked the interest, specifically or indirectly, of many investigators. A view substantiated by many researchers is that sight enhances balance performance.
Travis (32) found, utilizing the stabilometer, that in the situation where no visual cues were provided for twenty-two men and twenty-two women, the performance scores on the average were one-third as high as those with visual cues present. He therefore suggested that both static and dynamic equilibrium were greatly aided when visual cues were present. Cowell (5) found a correlation coefficient of .168 between total static balance on stick (eyes open) and the same total static balance on stick (blindfolded), and indicated vision to be an important factor in balance. Miles (26) further substantiated the importance of sight to balance, as did Bass (2).

Brammer (4), on the other hand, found a positive correlation of about .54 between station records made with the eyes open and those made at an earlier date with them closed. He concluded that "ability to maintain station with the eyes open tends to be accompanied by a like ability with them closed." Whelan (36) compared a group of blind subjects with a group of blindfolded sighted subjects and concluded that there was little difference in balance between the blind and sighted. He also concluded that, "the sense of balance in the blind probably does not become highly developed to compensate for the loss of sight, as do other faculties such as hearing and touch."

Another physiological factor that might affect balance was the potential influence of the menstrual cycle. Fearing
(13) found that the beginning of each menstrual cycle was "characterized by a sharp decrease in amount of sway," but offered no explanation for the circumstance.

**Anthropometrical.** Researchers have examined various mechanical factors influencing balance. Most commonly measured have been height and weight of subjects. Miles (26) surmised that "swaying is principally from the ankle, and that the taller and heavier subjects will show greater unsteadiness at the vertex." He concluded this from an experiment in which he artificially increased the height and weight of a subject, and found the factor of height to exert more influence than weight in the ratio of about four to one. Fearing (13) also found height to have a consistently higher correlation than weight with amount of sway in all planes and positions. However, all correlations with both height and weight were relatively low, indicating that other factors should have been considered. McCraw (25) found in his factor analysis of motor learning, which included balance test items, that a dominant factor was body size, height, and weight. An immediate relationship was not identified in this study, however.

Travis (32) stated that "weight and height have no bearing on sway scores, rotation scores, steadiness and manual pursuit." On the other hand, in another study (33), Travis discovered that "the heavy-weight or tall person has greater difficulty in controlling his postural balance."
than a light-weight or short person." Edwards (10) found that large size and greater than average weight of the body, when taken together, did seem to be related to increased amounts of sway. No correlation was found between height and amount of sway, however. Crowell (5) and Espenschade, Dable, and Schoendube (11) found neither height nor weight to be significantly related to dynamic balance.

Another approach used in the research of equilibrium involved sex differences correlated with balance performance. Miles (26) found that the advantages and disadvantages of men and women tend to counterbalance, and that the average results for adults of both sexes agree closely. Men, somewhat taller than women, appeared to have a disadvantage in scores. On the other hand, since they had longer, broader feet, and therefore a larger base, men compensated for their apparent disadvantage of height. Travis (33) reported a small sex difference found in favor of the women in stabilometer performance with weight controlled. Espenschade, Dable, and Schoendube (11), using a rail-walking test, found boys to improve more than girls; but, both sexes showed consistent growth.

Psychological.—Very little objective research was found in the literature regarding psychological factors affecting balance performances. One physical educator has attempted to analyze the effect of emotion on motor
skill. Jackson (20) found that "without question, the emotion of fear tends to make the individual give a performance similar to that of the beginner." He further reported that in one or two instances, as indicated in the questionnaire, fear apparently made the individual try harder, although the smoothness of the performance was undoubtedly affected. The questionnaire further indicated that fear was present in the majority of cases and was due to height, inadequate support, and imagination. The performance questionnaire revealed that fear among these subjects was most likely to be present in a beginner because the lack of experience tended to make the emotion more prominent. New stunts also caused various degrees of fear, especially the first few times they were attempted. Unfortunately the literature revealed no other studies investigating height and task performance, as factors relating to fear.

Chronological.—Comparisons of balance to maturity have been offered as supplementary findings in many studies. It has been recognized (22) that the complexity of balance and also the very wide range of changes in ability from childhood to middle or later years makes the measurement quite difficult. However, most investigators have found positive correlations between balance scores and chronological age. Edwards (10) found, in more than 1400 subjects, a clear increase of steadiness in standing erect as age
increased from three to twenty years. He also discovered some increase in sway for some of the oldest subjects. He concluded there was no great increase in static ataxia in subjects with advancing age if uncomplicated by other factors. Seashore (28) concluded from his investigatory proceedings, as measured by the beam-walking test, that balance function seemed to reach relative maturity rather early in adolescence. Espenschade, Dable, and Schoendube (11) were able to broaden Seashore's findings, and reported that, while scores showed a consistent gain with age, the rate of change from thirteen to fifteen was much less than that which occurred earlier or later. They further reported that "this same 'lag' appeared in both sets of data collected a year apart;" therefore, it seems doubtful that sampling was the cause. Cron and Pronko (6) agreed that balancing reactions improved with age, leveling off and showing a slight decline in the twelve to fifteen year old group. Johnson (21) and Matz (23) concurred and established a positive relationship of balance to chronological age.

Methods of Measuring Balance

Generally it has been acclaimed (1, 5, 14, 18, 27, 33, 39) that no one method satisfactorily measures the totality of balance. Various tools have been devised to gain insight about the balance phenomenon, as well as to objectively
measure the static and dynamic qualities of balance. Some tools, however, involve properties of both moving and non-moving balance.

**Static measures.**—Perhaps due to the greater ease in objective measurement, static equilibrium has received much attention in laboratory investigations. Miles\(^26\) related the use of an ataxigraph in 1919 to measure station. It was from this apparatus, that he formulated the Miles ataximeter, which could automatically accumulate all the anterior-posterior and lateral components of the movements of sway directly in millimeters. In Fearing's study\(^13\) to determine factors influencing static equilibrium, the Miles ataximeter was used. Investigations by Brammer\(^4\) and Estep\(^12\) also employed the ataximeter for station measurement.

White\(^37\) used an ataxigraph in his study of static ataxia as related to physical fitness. This instrument recorded movements made with the subject standing erect, without undue strain. The subjects wore a type of helmet which could be tightened securely to prevent movement on the head. Attached to the top of the helmet was a raised hook to which was fastened a string. The string ran over a pulley to the inkwriter of a spring-driven and governor-controlled kymograph which lay in a horizontal position within a suitable box. Movements of the subject were
translated into equivalent vertical lines on adding machine paper by the inkwriter. From the graphic recordings, an equation was formulated to objectively interpret the movements. Fisher, Birren, and Leggett (14) standardized the ataxigraph as a measure of testing static equilibrium; the retest reliability coefficient reported was .87.

Bass (2) devised a stunt-type static balance test called Stick Balance Test. The test was composed of twelve tasks. Tests one through four consisted of standing, single foot, crosswise on a 1 x 1 x 1 inch stick, on the ball of the foot. Tests five through eight consisted of standing on the ball of the foot, on the floor; and tests nine through twelve, standing, single foot, lengthwise of stick, on the ball of the foot. She suggested Test One, straight standing crosswise on stick with eyes opened, and Test Nine, straight standing on stick with eyes opened to be sufficient in testing static balance. Reliability for Test One was reported .901 and for Test Nine, .858.

Dynamic measures.—Many appraisals of dynamic equilibrium include rail or beam walking tests, as well as stunt-type moving balance tasks. Seashore (28) refined the Springfield Beam-Walking Test, which consisted of nine beams decreasing in size. Highest reliability of the test when the second fall-off score was used as the failure point on the test was found to be .89. Heath (17) reported a test of locomotor balance that consisted of three wooden rails.
In heel to toe fashion, subjects walked to the end of the beam. No reliability was reported. In her effort to measure gross motor development of infants and young children, Cunningham (8) utilized various balance tests for different age groups. The thirty months old test included walking upon two parallel 4 x 4 x 4 inch beams. Another task in this test was walking on double diverging beams without stepping off. At thirty-six months, the youths walked on 4 x 4 x 4 inch beams without stepping off more than twice. No reliability was reported. Fisher, Birren, and Leggett (14) also used a rail-walking tool to measure sensorimotor performance. Subjects were to walk the length of a rail which was one inch wide and ten feet long, placing heel to toe, with hands clasped behind the back. Performance was scored as the sum of the distance walked in ten trials. The retest reliability coefficient was .67. Katz (23), in her report of the "Effects of Gymnastics on the Motor Fitness of Boys", used the Cureton Balance Beam Test as a balance criterion. Cron and Pronko (6) used a balance board to investigate the development of the sense of balance in school children. The two by four, twelve foot long board, having no middle support, sagged and swayed somewhat. This required compensatory movements by the walker.
Bass (2) devised a stunt-type dynamic balance test called the Stepping Stone Test. The subject followed a specific pattern of leaping on designated feet and maintaining balance while in a small circle. Bass found this test to have a reliability of .952.

Scott (30) devised another stunt-type dynamic balance test called the Sideward Leap. Subjects leaped sideward, pushed a cork off a marked spot, held a balanced position, and finally leaped to their original position. The reliability coefficient was .88. Recognizing the need for a standardized tool for measuring an individual's ability to maintain steady balance while standing on an unstable platform, Travis (33) designed a stabilometer for dynamic balance measurement. The reliability of the stabilometer was ascertained by correlating the first trial with the second trial, the second trial with the third trial, and the third trial with the first trial for the entire group of college men and women. The coefficients were .86, .85 and .80 respectively.

Cowell (5) presented a force platform to measure the total amount of body movement occurring during the execution of balance. So sensitive was this instrument that it could detect the heart beat of a subject standing on the platform. When correlated among twenty-nine established balance tests, it was found to have a significant relationships with the
static balance on stick and total static balance on stick (blindfolded). In his attempt to establish a new balance test which would discriminate among selected groups of male college students, Slater-Hammel (31) used the Reynolds' **Balance Test**. This tool required subjects to balance on a teeter-board until a sequence of stimulus lamps had been matched. The task was timed. Heeschen (18) designed and used a balanciometer to measure balance. This instrument was essentially a wooden platform centered on a steel axle and mounted in a wooden frame, which was wired. The "teeter-totter" tool was equipped with an electric timer to record the number of seconds that the platform has been held in a balanced position. The low product-moment correlation coefficients resulting when the balanciometer was compared to the scores of the **Illinois Progressive Balance Beam Test**, the **Bass Stick Test**, and the **Springfield Beam-Walking Test** indicated that Heeschen's instrument evaluated something that had little bearing upon scores obtained on any of the other three tests of balance.

**Balance and Motor Skills**

Educators have continually sought to assess an individual's motor skill by analyzing ability, educability, fitness, coordination, and other variables. From the investigations, certain substantiations have been established concerning the relationships of balance to motor skills.
Alden, Horton, and Caldwell (1), in classifying college coeds into homogeneous groups via a motor ability test, first compiled a list of motor ability components secured from the judgements of twenty representative physical educators. Balance was included in this list. Garrison (15), in her study to improve balance ability through teaching selected exercises, found a positive but low relationship between motor ability and balance ability. Young (39) found that static balance also had a low but positive relationship with general motor ability. Scott (30) reported that significant correlations existed among motor agility, the Balance Stick Test, and the Balance Leap Test. Lauze (22) discovered that students who scored in the lowest quarter on the Scott Motor Ability battery made scores significantly lower than those in the upper quarter on a test of balance.

McCloy (24) named balance as a definite factor in motor educability. According to Bass (2), the Iowa Revision of the Brace Test (for motor educability) is highly loaded with four balance factors, suggesting a definite relationship.

Components of motor skills have further been analyzed through studies of motor coordination. Cunningham (8) recognized balance to be an important factor in measuring gross motor coordination, and, therefore included in her study several balance beam tasks. Cumbee (7) isolated
eight factors in an analysis of motor coordination; one factor was termed body balance. Heath (17) stated that "the test employed in this study singles out only one phase of motor coordination; namely, locomotor balance. . . ."

While Brammer (4) did not conduct a study of motor coordination or ability specifically, he did relate the importance of good motor control in the fitness of a man to fly. He acknowledged static equilibrium as a factor of motor coordination.

Hunt (19), recognizing balance and agility as both factors in motor skill, conducted a study to see if balance and agility are related. She found low but significant relationships between agility and both aspects of balance. These relationships were not high enough, however, to justify the administration of a single test for both abilities.

Since balance has been substantiated as an integral factor in motor skill and performance, it is only natural that investigators would then be curious as to the prominence of balance in specific sports skills. White (37) stated that "ability to succeed in athletics rests upon a number of bodily mechanisms working in a high degree of harmony. Among these is the factor of equilibrium." In his study, however, he reported no statistically significant difference in basic postural integrity resulting from a process of athletic training. Students selected by their coaches as having poor athletic ability appeared to have poorer
postural integrity than the skilled athletic group. Likewise, students who were unable to take physical education due to medical reasons appeared to have poorer basic postural integrity than highly skilled athletic group.

Travis (16) found that individuals reporting previous training in dancing, skiing, gymnastics and skating tended toward a performance far above normal on the stabilometer.

Valentine's study (34) substantiated Travis' findings. She found that skill rank in dance seemed significantly correlated with two measures of balance, the Balance Stick (eyes open) and the Balance Beam Test. She also found that as skill advanced in both ice skating and dance, certain specific balances improve significantly.

Garrison (15) reported that students' skill in badminton and modern dance did not seem to be affected by balance lessons, and that ability of students in square dance seemed to be unfavorably affected. Bass (2) found a low but positive relationship between static balance and rhythm rating. Gross and Thompson (16) discovered that the better and faster male swimmers had better dynamic balance than the slow swimmers, as determined by the Bass test of dynamic balance. Mumby (27) found that in balance and in ability to learn to balance, good wrestlers were somewhat better than poor wrestlers. However, individual differences in these abilities were not correlated significantly with judges' rating of wrestling in this study. Katz (23), in
determining the effect of gymnastics on motor fitness scores of young boys, found that balance increased over and above the average increment.

The number of studies reported in the literature is limited concerning studies designed to predict athletic performances. One such study was that designed by Wettstone (35) to predict potential ability in gymnastics and tumbling. Preliminary procedures in this study included the compilation of a list of the innate and the acquired qualities that a good all-around gymnast should possess. The components were suggested by coaches interested in gymnastics. The fifteen qualities receiving the highest number of votes were the ones selected for testing; kinesthetic sense and semi-circular canal function were among the attributes listed and tested. From his data, a test was constructed consisting of three elements, thigh circumference, strength test (consisting of chinning, height dipping, and thigh flexion), and the Burpee Test. This battery predicted potential ability in gymnastics with a multiple correlation of .79. The balance items were not included in this final battery. Since male subjects were used, strength items might have been expected to be the final predictors. These results might have differed had female subjects been used.
Upon reviewing the literature pertaining to human balance, researchers generally have agreed that some of the components involved in the function of balance are general eye-motor factors, general kinesthetic response factors, and a general ampullar sensitivity factor. Conclusions based upon investigations of the phenomenon of kinesthesia have been that balance is a most important component, and that a balance test would be included in any battery of kinesthesia tests.

From a physiological approach to the study of balance, it has generally been contended that balance can be maintained despite the loss of labyrinth receptors; it has also been suggested that visual sensations may supplement or substitute for the occurrence. Most investigators have related that visual cues greatly enhance balance performance. It has also been discovered that menstruation did not produce increased sway, but rather decreased sway at the beginning of each menstrual cycle. Another discovery concerning balance has been the positive relationship between balance and chronological age.

Anthropometrically, researchers have tended to agree that the heavy-weight or tall person has greater difficulty in controlling postural balance than does a light-weight or short person. Women usually seem to perform balance tasks better perhaps because of the height-weight advantage; however, men compensate for the height-weight disadvantage.
with their longer, broader feet furnishing them with a larger base.

Very little evidence has been reported regarding psychological factors affecting balance performance, either on ground level or in the air. One investigation (20) has reported that the emotion of fear tended to make an individual give a performance similar to that of a beginner due to height, inadequate support and/or imagination.

It has been generally acclaimed that no one method satisfactorily measures the totality of balance; thus, many tools have been developed and reported to measure various aspects of balance. Among the static balance instruments have been the Miles' Ataximeter, and Bass' Stick Test. Among the dynamic balance instruments have been Cowell's Force Platform, Reynolds' Balance Test, Heeschen's Balanciometer, Travis' Stabilometer, the Springfield Beam-Walking Test, Cureton's Balance Beam Test, Cron and Pronko's Balance Board, and various rail-walking tasks devised by Heath, Cunningham, and Fisher, Birren, and Leggett. Stunt-type dynamic measures were reported by Brace, Bass, and Scott.

Educators have reported balance to be an integral factor in motor ability, educatibility, fitness and coordination; and, positively related to sports skills such as swimming, wrestling, dance, ice skating, and gymnastics.
Further knowledge is needed regarding the relationship of balance to specific skills within sports, such as the role balance plays in the balance beam as a component of gymnastics.
CHAPTER BIBLIOGRAPHY


CHAPTER III

PROCEDURES

Subjects

The data for this study were obtained from ninety-four women students who selected a physical education course in gymnastics at North Texas State University during the spring semester, 1967. Seventy-eight of the subjects had had no previous gymnastic exposure prior to this study and were enrolled in a beginning gymnastic class. Sixteen of the subjects were enrolled in an intermediate class on the basis of their previous gymnastic experience. The amount of experience of the students in the intermediate class varied.

The subjects ranged in age from 17.2 to 22.7 years. All subjects participating in the testing program wore a leotard and were barefooted.

Tests and Instrumentation

The tests employed in this study were selected from balance tests frequently described in the physical education literature, and were selected on the basis of their validity in measuring a specific aspect of the balance parameter. Also, these tests were chosen on the bases of feasibility of construction and ease of administration.
Six major instruments, composed of one or more items, were used to appraise the static and dynamic balance of the subjects.

**Static Balance Assessment**

Static balance assessment was made by the use of stunt-type and stick tests. A variety of static balance tests was selected to insure a more complete appraisal of static balance performance.

**Stunt-type static balance measures.**—Balance Items Twelve, Eighteen, and Nineteen (Appendix A) from the original Brace Motor Ability Test were administered to all subjects. According to Brace (3, pp. 17-26), the criteria upon which the tests have been validated are a) judgment ratings by an instructor as to the general motor ability of 451 pupils, b) scores on a variety of athletic events, and c) comparisons of the scores of 56 athletic team members with those of a group of 395 pupils. The tests used in Brace's study had a correlation of .58 with the judgment rating criterion.

The subject was scored on each of two trials on a pass or fail basis for all items. Success on the first trial was scored as two; success on the second trial was scored as one. A zero was recorded for a failure.

**Stick static balance measures.**—Two balance instruments, a standardized stick test and a modified stick test
used in this study, were based on the Bass Stick Test for static balance: Test Nine, the transverse item.

The transverse item of the standardized stick test has a reported reliability coefficient of .856. In this test (Appendix B) the examinee placed the ball of her dominate foot transversely across a steel stick that was placed on the floor. The stick was one inch wide, one inch high, and twelve inches long. The subject placed her supporting foot in position and allowed the toe of the free foot to touch the floor. After a signal from the investigator the subject lifted her non-balancing foot and held a straight standing position with the eyes open. An examiner recorded the number of seconds the balance was maintained. Three trials were allowed and all recorded for later analysis. A total of the three trials was used as the score.

The Modified Stick Test (Appendix C) was designed similarly to the original standardized test, and a test-retest reliability of .97 has been obtained by Wyrick (15). A one by one by twelve inch steel stick was mounted three feet eleven inches above the ground on four legs supported by cross braces. (See Figure 1, page 40.) In order to support the body weight the entire apparatus was constructed of metal. In order for the subject to position herself on the mounted bar and to eliminate a strength variable,
Fig. 1—Subject balancing on Modified Stick Test
a step-ladder that was exactly as high as the balance apparatus was adjacent to it. The subject climbed the ladder and positioned the ball of her dominate foot transversely on the steel stick. When she removed her free foot from the step ladder, an examiner timed and recorded the number of seconds before she lost her balance and began falling to the ground or replaced her foot on the ladder. Safety precautions included a spotter, who stood behind the subject and served to break the subject's fall. If contact was made between subject and spotter, the examiner terminated the time trial. The sum of three trials constituted the Modified Stick Test Score.

**Dynamic Balance Assessment**

Dynamic balance was appraised by the use of stunt-type and beam tests. According to the rules of competition proposed by the Amateur Athletic Union of the United States (15, p. 114) and by the Division of Girls and Women's Sports of the American Association for Health, Physical Education, and Recreation (4, p. 147), an exercise routine on the balance beam must contain continuous movements with no more than three held positions, maintained for three seconds each. Because an official Olympic Balance Beam routine is thus composed of more dynamic than static balance tasks, more items for measuring dynamic balance were included in this study.
Stunt-type dynamic balance measures.—Balance Items One, Four, Seven, Nine, Thirteen, Fourteen, Fifteen and Twenty from the original Brace Motor Ability Test (Appendix A) were administered to all subjects. The criteria upon which the tests have been validated are the same as those mentioned for the static balance items. The reliability coefficient is also the same, as the reliability for the static and dynamic items were determined concurrently.

Another instrument selected to measure dynamic balance was the Sideward Leap Test as developed by M. Gladys Scott (16, pp. 320-22). The standardized Sideward Leap Test (Appendix D) had a test reliability of .88 when computed on alternate trials of a series of ten and stepped up by the Spearman-Brown formula.

A specific requirement for this stunt-type test was that the subject’s leg length was measured prior to testing. A standardized tape measure was used to establish the distance from the greater trochanter of the femur to the floor. Leg lengths were recorded on a cumulative data sheet. Students were aligned in the initial test position according to their specific leg lengths. From this starting point subjects leaped to a designated mark on the floor, immediately leaned forward and pushed a cork off another mark on the floor, held a balanced position for five seconds, and then leaped back to the initial mark. Six trials were allowed; three beginning on the
left. A successful trial was accredited with one point; a failure received no points. The final score was the sum of the six trials.

**Beam dynamic balance measure.**—The Modified Sideward Leap Test (Appendix E) was identical to the standardized Sideward Leap Test except that it was raised to the height of the Olympic Balance Beam. A large box, two feet by four feet with the initial starting marks painted on it, was placed on a table twenty-four inches from the beam. (See Figures 2 and 3, pages 44 and 45.) Together, box and table were three feet eleven inches high, the height of the Olympic Balance Beam. The subject performed the same tasks that were required in the standardized Sideward Leap Test. Safety precautions for this test included spotters on three sides of the subject and tumbling mats under the beam. A trial was not successful if the spotters physically aided the examinee at any time during the test.

**Olympic Balance Beam Skill Tests**

The criteria for Olympic Balance Beam performance were a non-timed Balance Beam Skill Test (Appendix F) and two Beam Speed Tests (Appendix G).

**Non-timed balance beam skills test.**—This test was composed of stunts progressing from a beginning to an advanced level. The classification of skill level was assessed by the authoritative jury technique. No less
Fig. 2—Subject in starting position of Modified Sideward Leap Test
Fig. 3—Subject displacing cork in Modified Sideward Leap Test.
than three gymnastic authorities (1, 4, 5, 6, 7, 9, 11, 13, 14, 17, 18, 19, 20, 22, 23) represented in the literature agreed upon the skill level of each of the fourteen stunts included in the entire Balance Beam Skill Test.

Subjects were rated on a pass or fail basis on each of the fourteen stunts. Credit was allowed if the essence of the stunt was completed, regardless of form, and without falling from the beam. To increase the range of scores, weights were applied to stunts representing varying skill levels. The scoring was computed from an arbitrarily derived equation: Skill Score = 1 (beginning stunts passed) + 1.5 (intermediate stunts passed) + 2 (advanced stunts passed). Subjects were allowed an unlimited number of trials, since the emphasis of this study was on final success and was not relevant to learning or practice. The apparatus used in these test items was a standardized Olympic Balance Beam.

Safety precautions included a spotter on each side of the beam, and tumbling mats under the beam. An attempt was recorded as a zero if at any time the spotters had to physically assist the subject.

Balance beam speed tests. — The final instrument used to assess balance was composed of two beam speed items (Appendix G). In order to better judge the skill of a
performer, a timed element was introduced as an additional factor in the skill performance of simple task combinations. The beam instrument, and safety precautions remained the same as for previously described beam tests. Reliability for Balance Beam Speed Test I from within-day reliabilities was .88; Balance Beam Speed Test II had a within-day reliability of .91.

Each Beam Speed Test required three trials. Subjects repeated the tasks until three scores for each test were obtained. The three trials were totaled for a final score. A failure was recorded if the subject fell off the beam, or improperly executed the task.

Methods

Organization of Classes

The three beginning gymnastic classes used in this study were carefully screened to eliminate subjects who had had previous balance beam experience. Those examinees eligible for the testing program were then divided alphabetically into one of four groups. The only intermediate class participating in this study was similarly divided into four groups.

Administration of Tests

Tests were administered to the four gymnastic classes during the spring semester, 1967. All testing occurred in
the North Texas State University Women's Gymnasium, room 109. For timed events, Hanhart Super 10 stopwatches were used. These watches had a start, stop, and reverse stem across the top, and measured to one-tenth of a second. The tests included 1) the eleven balance items of the original Brace Motor Ability Test, 2) Bass Stick Test, 3) Modified Stick Test, 4) Sideward Leap Test, 5) Modified Sideward Leap Test, 6) Balance Beam Skill Test, and 7) Beam Speed Tests I and II.

After a class stabilization period of two weeks all subjects completed the battery of balance tests according to the following schedule:

Day I Balance stunts of the Brace Motor Ability Test

Day II Two of the static or dynamic tests (Bass Stick Test, Modified Stick Test, Sideward Leap Test, Modified Sideward Leap Test)

Day III The remaining two balance tests, not taken the day before

In order to balance possible interaction effects among the standardized and modified tests, each of the four groups in each class began the testing session with a different test. Groups were rotated so that each combination of the two tests was experienced on each day by one of the groups.

Twelve weeks later, following instruction and practice in a comprehensive program of gymnastics, the Olympic
Balance Beam Skill Test and the Balance Beam Speed Tests I and II were administered to each subject. The skill test was administered one day; the speed tests were administered a following day.

**Brace Motor Ability Test.**—The administrative procedures suggested by Brace were used. Subjects selected other subjects as partners who judged, scored, and recorded their results. The partners, forming two parallel lines, faced each other. One line was arbitrarily designated as active first; the second line then scored. Subsequently, duties reversed.

Score sheets and pencils were provided for each subject and scoring techniques were explained. Before the scoring of each item, directions were read and demonstrations presented. Time allotted for questions followed. The eleven items were tested in their original order. Following completion of the stunt tests, the researcher collected the score sheets and checked the tallies.

**Bass Stick Test.**—A volunteer, previously trained for this test presentation, demonstrated and explained the balance test to each group as it arrived at the testing station. Each trial was timed by a stopwatch.

**Modified Stick Test.**—A volunteer, prepared beforehand for this test administration, explained and demonstrated to each group the balance tasks involved. Each trial was timed by a stopwatch.
Sideward Leap Test.—The researcher explained and demonstrated to each group the procedures for this test prior to the trials. Students from each group served as spotters for one another. Timed trials were recorded.

Balance Beam Skills Test.—Two weeks prior to actual testing, the assigned gymnastic teacher for each class demonstrated and/or explained all tasks involved in the three levels of this skills test and the two Beam Speed Tests. Examinees were encouraged to practice all stunts; a list of tasks in sequence of testing was posted on the wall near the beam activity area.

Before recording results, the researcher again demonstrated and/or explained stunts involved. If a subject were not able to pass a stunt on the trial day, she was allowed to return another day and try again. In order to conserve time, subjects were asked to perform only those intermediate and advanced items that they had practiced and achieved. If a subject indicated no success attainment for a task, a zero was recorded. Spotters were used throughout the skill tests.

Balance Beam Speed Tests I and II.—Following the completion of non-timed Balance Beam Skill Tests, the Speed Tests were demonstrated, explained and administered by the researcher. A double thickness of tumbling mats was provided at the far end of the beam. Spotters were provided, also.
Analysis

Preparation of Data

The data were compiled and computed at the North Texas State University Computer Center and at the Texas Instruments Computer Division, Richardson, Texas. From this compilation of data, two IBM cards were prepared for each subject. The IBM cards contained the following data: total score for balance items of the Brace Motor Ability Test, three trial scores for the Bass Stick Test each to the nearest tenth of a second, three trial scores for the Modified Stick Test each to the nearest tenth of a second, total score for the Sideward Leap Test, total score for the Modified Sideward Leap Test, the best score for the Bass Stick Test to the nearest tenth of a second, the best score for the Modified Stick Test to the nearest tenth of a second, Stick Discrepancy score, total score for Balance Beam Skill Test, three trials of Balance Beam Speed Test I to the nearest tenth of a second, three trials of Balance Beam Speed Test II each to the nearest tenth of a second, total Bass Stick Test trials, total Modified Stick Test trials, total trials of Beam Speed Test I, and total trials of Beam Speed Test II.

Tests of Hypotheses

To determine whether relationships existed among the various balance tests, the null hypothesis that the
correlations reflecting those relationships were not significant was tested. An intercorrelation matrix was established and coefficients greater than .21 were considered to be significant at the .05 level (8, p. 581). Any coefficient that was both significant and substantial in magnitude might indicate the existence of a relationship among balance tests.

Beginners' and intermediates' scores for the standardized and modified balance tests, and the skill tests were compared by a t test for uncorrelated means. Values greater than 1.99 were accepted as indicating significant differences between the group means at the .05 level (8, p. 581).

The t test for correlated means among all subjects was computed to determine if a significant difference was present between the Sideward Leap Test and the Modified Sideward Leap Test; and between the Bass Stick Test and the Modified Bass Stick Test.

By subtracting the Modified Bass Stick score from the standardized Bass Stick Test score; a discrepancy score was computed. The Sideward Leap Discrepancy score was derived by subtracting the Modified Sideward Leap score from the standardized Sideward Leap Test score. The two discrepancy scores were examined as potential predictors of beam performance.
To determine if any other balance test or combination of tests would significantly predict Olympic Balance Beam performance, a multiple regression analysis was examined. The Balance Beam Skill Test served as the dependent variable to be predicted by the independent variables of static balance tests, dynamic balance tests, and speed scores. The .05 level was selected as the level necessary to reject the null hypothesis that there was no test or combination of tests capable of significantly predicting Olympic Balance Beam performance.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

RESULTS AND DISCUSSION

Results

The results of this study and the discussion of these results are based upon the statistical analyses previously described in Chapter III and statistical tests of the null hypotheses specified on pages 8 and 9. Both of the results and the ensuing discussion were considered in terms of the study's purposes, which were a) discovery of relationships existant among various balance tests, b) determination of the effect that previous beam experience had on balance performance, c) determination of the effect of height on balance performance, and d) identification of predictors of Olympic Balance Beam performance. In all cases the .05 level was accepted for rejection of null hypotheses.

Relationships Among Variables

As may be seen in Table I, several significant relationships existed among the ten variables reported in the correlation matrix. These relationships varied from low to moderate with the exception of that of the Modified Sideward Leap and the Sideward Leap discrepancy score. The magnitude of this \( r \) coefficient is spuriously high, however, since the discrepancy score was derived by arithmetical manipulation of the Sideward Leap and the Modified Sideward Leap
### TABLE I

CORRELATION MATRIX FOR BALANCE AND SKILL TESTS (N=94)

<table>
<thead>
<tr>
<th>Test</th>
<th>M</th>
<th>SD</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brace Balance Items (Total)</td>
<td>11.39</td>
<td>2.44</td>
<td>.47</td>
<td>.20</td>
<td>.05</td>
<td>.32</td>
<td>.49</td>
<td>.45</td>
<td>.39</td>
<td>-.39</td>
<td>-.31</td>
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<td>2. Sideward Leap Test</td>
<td>2.86</td>
<td>1.72</td>
<td>.34</td>
<td>-.02</td>
<td>.76</td>
<td>.28</td>
<td>.33</td>
<td>-.33</td>
<td>-.31</td>
<td>-.23</td>
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<tr>
<td>3. Modified Sideward Leap Test</td>
<td>1.10</td>
<td>1.21</td>
<td>-.01</td>
<td>-.36</td>
<td>.18</td>
<td>.24</td>
<td>.21</td>
<td>-.35</td>
<td>-.26</td>
<td></td>
<td></td>
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<tr>
<td>4. Bass Stick Test</td>
<td>38.55</td>
<td>13.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.01</td>
<td>.18</td>
<td>.59</td>
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<tr>
<td>Discrepancy Scoreb</td>
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<td></td>
<td></td>
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<tr>
<td>5. Sideward Leap Test</td>
<td>4.77</td>
<td>1.74</td>
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<td></td>
<td></td>
<td></td>
<td>.16</td>
<td>.16</td>
<td>.18</td>
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<tr>
<td>Discrepancy Scoreb</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>6. Olympic Balance Beam Skill Test</td>
<td>6.91</td>
<td>2.59</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>.24</td>
<td>.08</td>
<td>-.49</td>
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<td>7. Bass Stick Test</td>
<td>24.73</td>
<td>22.45</td>
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<td></td>
<td></td>
<td>.47</td>
<td>-.30</td>
<td>-.26</td>
</tr>
<tr>
<td>(Total of 3 trials)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Modified Bass Stick Test (Total of 3 trials)</td>
<td>19.08</td>
<td>21.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.23</td>
<td>-.25</td>
<td></td>
</tr>
<tr>
<td>9. Balance Beam Speed Test I (Total of 3 trials)</td>
<td>12.91</td>
<td>3.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10. Balance Beam Speed Test II (Total of 3 trials)</td>
<td>13.44</td>
<td>4.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

r>.21=p<.05a


b Discrepancy Score: this score was computed by subtracting the modified test score from the standardized test score and was used to indicate a potential effect that height of task had on balance performance.
scores and was, in reality, a portion of the Sideward Leap Test score. As was expected, the only other high correlation was that between the two Beam Speed Tests (r=.80). These two tests were specially constructed to represent equivalent forms of a test to measure speed; thus, the coefficient of .80 served as an indication of the reliability of these speed tests more than as an indication of the relationship between two of the variables.

The negative coefficients indicating relationship of variables nine and ten with the other variables were due to the fact that the superior score on these two variables was the lowest time rather than the highest.

Effects of Experience on Performance

It was of interest to determine if a significant difference existed between performances of beginner and intermediate subjects on each of the variables. These results are reported in Table II. Performance on only the three tests of Sideward Leap, Olympic Balance Beam Skill Test, and the Balance Beam Speed Test I discriminated significantly between beginner and intermediate subjects. On all three variables, the intermediate group's mean score was superior to that of the beginner's. The intermediates were a unit of measure higher than the beginners on the Sideward Leap Test, two units of measure higher on the Olympic Balance Beam Skill Test, and two
### TABLE II

**Means, Standard Deviations and the Significance of Difference Between the Means of Beginner and Intermediate Groups on Tests of Balance and Skill**

<table>
<thead>
<tr>
<th>Test</th>
<th>Mean of Beginner Group</th>
<th>Standard Deviation of Beginner Group</th>
<th>Mean of Intermediate Group</th>
<th>Standard Deviation of Intermediate Group</th>
<th>t ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Brace Balance Items (Total)</td>
<td>11.20</td>
<td>2.45</td>
<td>12.31</td>
<td>2.17</td>
<td>1.66</td>
</tr>
<tr>
<td>2. Sideward Leap Test</td>
<td>2.69</td>
<td>1.73</td>
<td>3.69</td>
<td>1.40</td>
<td>2.13*</td>
</tr>
<tr>
<td>3. Modified Sideward Leap Test</td>
<td>1.06</td>
<td>1.25</td>
<td>1.25</td>
<td>.97</td>
<td>0.55</td>
</tr>
<tr>
<td>5. Sideward Leap Test -- Discrepancy Score b</td>
<td>4.62</td>
<td>1.75</td>
<td>5.14</td>
<td>1.54</td>
<td>1.76</td>
</tr>
<tr>
<td>6. Olympic Balance Beam Skill Test</td>
<td>6.65</td>
<td>2.23</td>
<td>8.19</td>
<td>3.60</td>
<td>2.20*</td>
</tr>
<tr>
<td>7. Bass Stick Test (Total of 3 trials)</td>
<td>24.01</td>
<td>22.36</td>
<td>28.24</td>
<td>22.57</td>
<td>0.68</td>
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<tr>
<td>8. Modified Bass Stick Test (Total of 3 trials)</td>
<td>19.14</td>
<td>22.89</td>
<td>18.81</td>
<td>9.29</td>
<td>0.05</td>
</tr>
<tr>
<td>9. Balance Beam Speed Test I (Total of 3 trials)</td>
<td>13.27</td>
<td>3.67</td>
<td>11.66</td>
<td>2.69</td>
<td>2.16*</td>
</tr>
<tr>
<td>10. Balance Beam Speed Test II (Total of 3 trials)</td>
<td>13.77</td>
<td>5.14</td>
<td>11.68</td>
<td>2.90</td>
<td>1.46</td>
</tr>
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</table>

*Significant at .05 level 

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**a** Probability necessary for significance at the .05 level is .99 (taken from Guilford, J. P., *Fundamental Statistics in Psychology and Education*, 1965, p. 581)

**b** Discrepancy Score: this score was computed by subtracting the modified test score from the standardized test score and was used to indicate a potential effect that height of task had on balance performance.
full seconds faster on the Beam Speed Test I.

The beginners and intermediates were significantly different on the Sideward Leap Test and the Balance Beam Speed Test, but the intermediates were not significantly superior on the measures of static balance. Although both groups displayed almost equal standard deviations of approximately twenty-two seconds on the Bass Stick Test, their standard deviations differed considerably on the Modified Bass Stick Test. The beginners were more than twice as variable when balancing 3'11" above the ground as the intermediates were. The Olympic Balance Beam Skill Test, constructed by the investigator, also significantly discriminated between the beginner and intermediate subjects. The standard deviations of both groups on the skill test indicated that the intermediates were more variable and displayed a wider range of scores.

Another point of interest was that on the first Beam Speed Test the intermediate group was significantly faster than the beginning group, but this was not true on the second Balance Beam Speed Test. It should be noted that both groups increased in variability on the second speed test, as is indicated by the intermediate group's increased standard deviation from 2.69 to 2.90 seconds, and the beginning group's increased standard deviation from 3.67 to 5.14.
Effects of Height on Performance

A t test of the correlated means indicated that all subjects performed significantly better on the floor than on the apparatus. The t ratio necessary to reject the null hypothesis at the .05 level was 1.99. The t ratio between the Sideward Leap Test and Modified Sideward Leap Test was 9.84; the t ratio between the Bass Stick Test and Modified Stick Test was 2.43.

Predictions of Olympic Beam Performance

The multiple regression analysis utilized to predict Olympic Balance Beam ability is displayed in Table III. The most effective single predictor was the Modified Sideward Leap, whereas the superior combination of tests included the Sideward Leap Test and the Modified Sideward Leap Test. It may be noted in the column that displays the R ratio, that the addition of other variables increased the superiority of prediction by only one one-hundredth of a point. It may also be noted in the F level column, that all predictors added significantly to prediction. The equation for prediction established on the basis of these results is: $\tilde{Y} = 16.78 + .46 \text{(score on Modified Sideward Leap Test)} + .40 \text{(score on Sideward Leap Test.)}$
### TABLE III

MULTIPLE REGRESSION ANALYSIS USING BALANCE AND SPEED TESTS TO PREDICT OLYMPIC BALANCE BEAM PERFORMANCE (N=94)

<table>
<thead>
<tr>
<th>Predictors</th>
<th>$R^2$</th>
<th>$R$</th>
<th>Necessary Level of Significance</th>
<th>SE of Estimate</th>
<th>$F$ Level</th>
<th>$b$ Weight</th>
<th>Student t</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>.56</td>
<td>.75</td>
<td>.27</td>
<td>4.50</td>
<td>116.11b</td>
<td>.46</td>
<td>6.44</td>
</tr>
<tr>
<td>3, 2</td>
<td>.66</td>
<td>.81</td>
<td>.31</td>
<td>3.99</td>
<td>26.23b</td>
<td>.40</td>
<td>3.39</td>
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<tr>
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<td>.82</td>
<td>.34</td>
<td>3.89</td>
<td>5.76b</td>
<td>.59</td>
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<td>.83</td>
<td>.37</td>
<td>3.81</td>
<td>4.71b</td>
<td>.11</td>
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<td>.85</td>
<td>.41</td>
<td>3.61</td>
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<td>.86</td>
<td>.42</td>
<td>3.52</td>
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<td>.86</td>
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<td>4.20b</td>
<td>.31</td>
<td>2.08</td>
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<tr>
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<td>.87</td>
<td>.46</td>
<td>3.44</td>
<td>.74</td>
<td>.86</td>
<td></td>
</tr>
</tbody>
</table>

- **Legend:** 1=Brace Balance Items (Total); 2=Sideward Leap Test; 3=Modified Sideward Leap; 4=Bass Stick Test--Discrepancy Score; 5=Sideward Leap Test--Discrepancy Score; 6=Bass Stick Test (Total of 3 trials); 7=Modified Bass Stick Test (Total of 3 trials); 8=Balance Beam Speed Test I (Total of 3 trials); 9=Balance Beam Speed Test II (Total of 3 trials).

- **Significant at the .05 level**

- **Discrepancy Score:** this score was computed by subtracting the modified test score from the standardized test score and was used to indicate a potential effect that height of task had on balance performance.

\[ \bar{y} = 16.78 + .46 \text{ (score on Modified Sideward Leap)} + .40 \text{ (score on Sideward Leap Test)} \]
Discussion

Relationships Among Variables

This study substantiates previous findings (1, 4, 6, 7, 9, 11, 13) that no one existing test of balance is sufficient to assess the motor performance component referred to as balance. Although it is improper to directly compare the magnitude of r coefficients, the relationships among balance tests in this study that were expressed by r coefficients ranging from -.33 to .47 were more in agreement with Heeschen (7) and Bass (2) than Drowatzky and Zuccato (5). Heeschen reported a range of -.47 to .55. While Drowatzky and Zuccato established a range of from -.19 to .30, Bass's intercorrelations ranged from -.27 to .75. Differences may be attributable as much to varying degrees of maturation in the seventh grade girls utilized as subjects in Drowatzky and Zuccato's study as to discreteness of the balance tests utilized in all the studies.

Finally, the results of this analysis justified the rejection of Hypothesis I, as all variables except the correlation of the Beam Speed Tests, and the Modified Sideward Leap Test and the Sideward Leap Test discrepancy score, were not significantly related.

Effects of Experience on Performance

The Olympic Balance Beam Skill Test and the Balance Beam Speed Test I were expected to discriminate between
the beginner and intermediate groups, but the Sideward Leap Test also discriminated between these two groups. It is interesting to note that all three tests were classified as tests of dynamic balance, indicating that experience may be helpful in the more coordinated aspect of balance appraisal. The large variability within both groups on the measures of static balance may have contributed to the failure of these items to discriminate between the two skill groups. While discrimination was evident between the beginners and intermediates on the first speed test, no significant difference between them was computed for the second test. A possible explanation might be that beginners gained enough experience from the first test to prepare them somewhat for the second beam speed performance. Another explanation may lie in the fact that the beginners were so much more variable on the second beam speed test than on the first. Their standard deviation increase was greater from the first speed test to the second than was the intermediate groups' increase. Apparently many factors such as experience, newly established confidence, newly established fears, changed motivation, varying rates of learning, varying perceptions of the problem at hand, and many other variables may have contributed to the beginner's performance on Beam Speed Test II. This indicates that the test order should have been rotated, so that one-half the
beginners experienced Beam Speed Test I first, and the other half experienced Beam Speed Test II first.

The Sideward Leap Test, just as the Reynolds' Test (12), is classified as a test of dynamic balance. The findings of this study that implicate the Sideward Leap Test as a discriminator of motor skill groups concur with those reported by Slater-Hammel (12). He found that the Reynolds' Test discriminated between physical education majors and non-physical education majors. The physical education majors were considered to be a high skill group. The Sideward Leap Test as used in this study discriminated between intermediate and beginner balance beam performers. The fact that the Olympic Balance Beam Skill Test also discriminated between these two groups provides convincing evidence that tests of dynamic balance differentiate between motor skill groups.

Thus as a result of this analysis, the rejection of Hypothesis II was justified; experience does seem to appreciably affect balance performance.

Effects of Height on Performance

Raising the height of the balance tests appreciably affected subjects' performances on each of the tasks. An indication as to why the standardized scores were superior to the modified scores might be a consideration of the psychological attitude of the subject regarding height. This
could relate to Jackson's (8) questionnaire findings, indicating subjects' acknowledgement of a fear of height in selected gymnastic situations. From the investigator's observation, some subjects appeared to be more attentive and to try harder as a result of the increased height of the task, while others appeared to be so conscious of the height increase that their performance was impaired. Future investigations of this nature might analyze the data in terms of those subjects whose scores did not change at all in comparison to those subjects whose scores radically increased or decreased. Analyses of this type might indicate that these subjects whose scores did not change at all might also be those subjects who had the superior skill.

On the other hand, the low correlation between the standardized static and dynamic balance tests and their modifications suggests that when these tests are raised above the floor they measure different abilities. Perhaps these tests should be considered tests of motor coordination rather than tests of dynamic balance.

Finally the results of this analysis justified the rejection of Hypothesis III, as the raising of the balance tests appreciably affected subjects' performances on each of these tasks.
Prediction of Olympic Beam Performance

The two balance tests best predicting beam skill were tests of dynamic balance. This was expected, since the literature (3, 10) reveals balance beam performance to be classed generally as dynamic balance. This was somewhat substantiated by the fact that the Bass Stick Test for static balance and its modified test were very poor predictors of balance beam skill. Generally, it appeared that the tests of dynamic balance, both on the floor and in the air, were the best predictors of Olympic Beam performance. But the next best two were both of the discrepancy measures, indicating that a score that represents the difference in the subject's performance up high and on the floor is a beneficial addition in the prediction of beam performance. If time were not a criterion in test selection, it would seem that a predictive battery that included both the Sideward Leap Test, its modification, and the Bass Discrepancy Score would be a practical and predictive battery of tests to use in selecting potentially successful balance beam performers.

Thus, as a result of this analysis, the rejection of Hypothesis IV was justified; a significant predictor of Olympic Balance Beam performance was found among the balance tests administered in this study.
Finally, ability of the neophyte beam performer to function at a height of 3'11" above the floor appears to play a significant role in the prediction of future Olympic Beam success. It may be postulated that some psychological parameter such as courage, determination, competitive spirit, poise during stress, or emotional control may be reflected in good scores on the Modified Sideward Leap Test. The same psychological and physical abilities that enable a performer to be successful at balancing 3'11" may be those attributes that are requisite to becoming a successful Olympic Balance Beam performer. Some caution should be expressed in the interpretation of these results, since the skill level on both the beginning and intermediate level was relatively low in comparison to excellent beam performers. Whether these tests would predict championship potential or discriminate at championship levels is yet to be determined.
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CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

In order to contribute additional information regarding balance function and performance, this study proposed a) to discover any relationships existing among various balance tests, b) to determine any effect that previous balance beam experience had on balance performance, c) to determine any effect that task height had on balance performance, and d) to identify predictors of Olympic Balance Beam performance.

Six major instruments were used to appraise static and dynamic balance. They were the eleven balance items identified in the original Brace Motor Ability Test; the Bass Stick Test for static balance; a Modified Bass Stick Test; the Sideward Leap Test; a Modified Sideward Leap Test; and two Balance Beam Speed Tests. A Balance Beam Skills Test was constructed to assess skill on the Olympic Balance Beam.

Ninety-four women students who selected a beginning or intermediate gymnastics physical education course at North Texas State University during the spring semester, 1967 were selected as subjects. Seventy-eight women, reporting no previous exposure to the Olympic Balance Beam.
Beam were grouped as beginners; sixteen subjects, reporting previous beam experience were grouped as intermediates.

The null hypotheses were, in general, that the intercorrelations of the balance tests would be zero; that people with previous experience on the Olympic Beam would not perform significantly different on balance tests from those possessing no previous balance beam experience; that there would be no significant difference in the means obtained from performance on the standardized tests; and, that there would be no balance test or combination of tests capable of significantly predicting Olympic Balance Beam performance.

The data were statistically treated, by the North Texas State University Computer Center, Denton, Texas and the Texas Instruments Computer Division, Richardson, Texas. Results of the analysis of the data revealed that no strong relationship existed among balance tests. The results of the t tests rejected the null hypothesis that no significant difference exists between the scores of the beginners and intermediates for performances of the Sideward Leap Test, the Olympic Balance Beam Skill Test, and the Balance Beam Speed Test I. The null hypothesis that no significant difference exists between the scores made on the Sideward Leap Test and Modified Sideward Leap Test, and between scores made on the Bass Stick Test and the Modified was also rejected. The hypothesis of this study,
that a measure of balance ability might be an efficient predictor of balance beam performance was also rejected; the most significant predictor reported was the Modified Sideward Leap, and the best combination of predictors were the Modified Sideward Leap and the Sideward Leap tests.

Conclusions

On the basis of results from the analysis of the relationships of standardized and modified balance tests to Olympic Balance Beam performance, the following conclusions seem justified:

1. Relationships among standardized tests of static and dynamic balance, and modified tests of balance, substantiate the findings of previous investigators regarding the inefficiency of any single existing test to assess balance ability.

2. Raising the Bass Stick Test and the Sideward Leap Test to a height of the Olympic Balance beam (3'11'') significantly affects individuals' scores on these tests.

3. The tests of dynamic balance investigated in this study may be efficient predictors of potential Olympic Balance Beam skill on a beginning and intermediate level.

4. Raising the Sideward Leap Test to the height of the Olympic Balance Beam significantly increases its predictive efficiency.

5. The combination of the Sideward Leap Test and its modification was the best predictor of those utilized in this
study to predict beam performance.

Recommendations for Further Study

As a result of this study, the following recommendations are presented:

1. Further studies similar to the present study should be undertaken using other tests that appraise human balance.

2. The data collected for this study should be subjected to a factor analysis in order to determine any specific factors which may be common to these tests.

3. Several psycho-physiological responses should be obtained prior to and during a task performance in order to determine if performance is affected by emotional responses or lack of skill.

4. This study be replicated using advanced gymnasts, as well as beginners and intermediates.

5. The test order for Beam Speed Tests I and II should be rotated among subjects in order to eliminate any learning, newly established fears, newly established confidence, or other similar variables that may affect the subject’s responses on the second test.

6. This balance battery should be utilized in the prediction of other women’s Olympic events, as the Uneven Parallel Bars, Floor Exercises, and Vaulting.
APPENDIX A

Balance Items of the
Brace Motor Ability Test*

ITEM ONE
Directions: Walk in straight line, placing the heel of one foot in front of and against the toe of the other. Start with the left foot. Take ten steps in all, five with each foot. Eyes open.

Failure: 1. Losing the balance and stepping out of line
2. Not walking in a straight line
3. Not placing heel to toe

ITEM FOUR
Directions: Stand. Fold the arms behind the back. Kneel onto both knees. Get up without losing the balance or moving the feet about.

Failure: 1. Losing the balance either going down or getting up
2. Moving the feet after standing up
3. Unfolding the arms

ITEM SEVEN
Directions: Stand with 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.

Failure: 1. Failure to get all the way around
2. Moving the feet after they strike the floor

ITEM NINE

Directions: Stand on the right foot. Grasp the left foot behind the right knee. Bend and touch the left knee to the floor, and stand up without touching any other part of the body to the floor, or losing the balance.

Failure: 1. Touching the floor with any part of the body except the left knee  
2. To touch properly and stand with right leg straight, and without losing the balance.

ITEM TWELVE

Directions: Stand, kick the right foot up so that the toes come at least level with the shoulders. Do not fall down on the floor.

Failure: 1. Failure not to kick as high as the shoulders  
2. Falling down and touching the floor with any part of the body other than the feet.

ITEM THIRTEEN

Directions: Stand on the left foot. Bend forward and place both hands on the floor. Raise the right leg and stretch it back. Touch the head to the floor, and regain the standing position without losing the balance.

Failure: 1. Inability to touch the head to the floor  
2. Losing the balance and having to touch the right foot down or step about.

ITEM FOURTEEN

Directions: Stand with both feet tight together. Bend down, extend both arms down between the knees, around behind the ankles, and hold the fingers together in front of the ankles without losing the balance. Hold this position for five seconds. (Counted by scorer)

Failure: 1. Falling over  
2. Failure to touch and hold the fingers of both hands together  
3. Failure to hold the position for five seconds.
ITEM FIFTEEN

Directions: 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.

Failure: 1. Failure to make a full turn and land facing in the same direction as at the start
2. Losing the balance and having to step about to keep from falling

ITEM EIGHTEEN

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

Failure: 1. Losing the balance
2. Taking the right foot down
3. Opening the eyes or removing the hands

ITEM NINETEEN

Directions: Take a squat rest position. That is, place the hands on the floor between the knees and close to the feet. Bend the elbows slightly and place the body on the hands. Hold the position for five seconds (as counted by the scorer).

Failure: Failure to keep the body off the floor for five seconds
ITEM TWENTY

Directions: Stand on the left foot with the right foot extended forward off of the floor. Sit down on the heel of the left foot, without touching the right foot or hands to the floor. Stand full up without losing the balance.

Failure:
1. Failure to sit all the way down on the left heel
2. Touching the right foot or hands to the floor
3. Failure to stand up with left leg straight before touching the right foot.
APPENDIX B

Bass Stick Test*
for static balance

Description

1. Signals for starting the tests
   a. At the word "ready," the subject places her supporting foot in the proper position, and touches the toe of the free foot to the floor.
   b. At the word "go," the subject lifts her free foot and holds the prescribed position as long as possible.

2. Positions of the static test
   a. Straight standing, eyes open
   b. Single foot, crosswise on stick, ball of foot

Scoring

1. The number of seconds that the balance is held is noted by the examiner and recorded.

2. Three trials allowed.

APPENDIX C

Modified Stick Test
for static balance

This test is modified version of the Bass Stick Test. The stick (one inch wide, one inch high, twelve inches long) that is utilized in the Bass Stick Test is raised to a height of 3'11".

Directions are modified to instruct the subject to mount the balance instrument by means of a ladder, exactly the height of the elevated stick.

Scoring procedures are the same as for the standardized Bass Stick Test. (See illustration on page 81.)
APPENDIX D

Sideward Leap Test* for dynamic balance

Description

1. Place left foot on mark X; leap sideward and land on A with right foot; immediately lean forward and push the cork off spot B; hold balanced position for five seconds, either forward or erect position. (See illustration on page 83.)

2. Three trials are given to the right, three to the left; and then task is repeated, three to the right and three to the left.

Failures

1. Fail to cover A on the leap
2. Move the foot after landing on A
3. Fail to lean forward and to move the cork from B immediately
4. Rest the hand on the floor at any time
5. Fail to hold the balance five seconds
6. Fall down

Scoring

1. Score is one point for each successful trial
2. Six trials allowed; points totaled for final score

APPENDIX E

Modified Sideward Leap Test
for dynamic balance

This is a modified version of the standardized Sideward Leap Test, in that the same test has been innovated to the level of the Olympic Balance Beam.

Directions have been modified to instruct the subject to leap from the box onto the Olympic Balance Beam, performing the same tasks as prescribed in the Sideward Leap Test.

Scoring procedures are also as in the standardized test. (See illustration on pages 85 and 86.)
APPENDIX F

Olympic Balance Beam Skills Test
Beginning, Intermediate, Advanced Levels

BEGINNING LEVEL

1. WALK
   Description: The subject walks from one end of the beam to the other in any manner
   Failure: 1. To fall off the beam
            2. To break rhythm
            3. To use another locomotor pattern other than a walk

2. PIVOT TURN
   Description: The subject walks to the end of the beam, rises on the toes and pivots 180° in her preferred direction.
   Failure: 1. To fall off the beam
            2. To pivot on only one foot
            3. Not to complete 180° turn

3. RUN
   Description: The subject runs from one end of the beam to the other in any manner.
   Failure: 1. To fall off beam
            2. To break rhythm
            3. To use a locomotor pattern other than a run

4. FRONT SCALE
   Description: The subject stands, balanced on one leg, with the other leg raised to full extension in back of her body. The subject bends forward so that the upper trunk is approximately parallel to the beam; arms are extended forward
Failure: 1. To fall off the beam
2. Not to maintain a balanced position

5. **GRAPEVINE LEFT**

Description: Positioned at the end of the beam, leading with her left side, the subject steps first to the left side with her left foot; next, her right foot steps behind the left. The subject again steps left with her left foot, then crosses in front of her left foot with her right.

Failure: 1. To fall off the beam
2. To break rhythm
3. To used any other locomotor pattern

**INTERMEDIATE LEVEL**

1. **STEP LEAP**

Description: The subject performs a step-leap pattern the length of the beam, beginning on her preferred foot.

Failure: 1. To fall off the beam
2. To break rhythm
3. To change feet
4. To use any other locomotor pattern

2. **CAT WALK**

Description: The subject raises forward one bent leg; the other leg quickly follows, with knees alternately raised to a height of the hips.

Failure: 1. To fall off the beam
2. To break rhythm, with long hesitations
3. To use another locomotor pattern

3. **BACKWARD ROLL**

Description: From a supine position on the beam, the subject pulls on the beam with her hands, raising her extended legs overhead into a tucked or piked position and rolling over onto one shoulder. The subject may recover into a knee scale or squat position.
Failure:  
1. To fall off beam  
2. Not to completely roll over, landing on the beam

4. **HALF TURN ON DOMINATE FOOT**

**Description:** Subject walks onto beam, and positions her feet so that she can turn in her preferred direction on the ball of one foot.

**Failure:**  
1. Not to turn 180° on the beam  
2. To fall off the beam  
3. To replace her non-dominant foot before she has turned 180°

5. **HEADSTAND**

**Description:** From a squat or kneel, the subject takes time to position her head and hands on the beam. In any manner she raises her legs so that they fully extend above her head; this balance is maintained until the examiner is satisfied the task was achieved. The subject then comes down onto the beam in any manner.

**Failure:**  
1. Not to fully extend legs overhead  
2. To fall off the beam  
3. Not to come down onto beam after task completion

**ADVANCED LEVEL**

1. **BACK WALKOVER**

**Description:** The subject stands with one foot slightly in front of the other; the head drops backward, arms reach back over the head and hips are thrust forward. Hands reach for the beam as the front foot and leg swing forward and upward over the arms and head of the subject, until this lead leg contacts the beam; the other leg follows. The subject lifts her head upward, as she pushes vigorously off the beam thereby raising her upper torso.
2. HANDSTAND

Description: Subject maintains a balanced position on her hands with legs fully extended. Subject recovers from task on the beam in any manner.

Failure: 1. To fall off the beam
2. Not to maintain balance while inverted
3. Not to return to beam in recovery

4. FULL TURN RIGHT

Description: Subject walks to center of beam and on the ball of her right foot, turns 360° in her right direction. Left foot should not touch the beam until the subject returns to the direction she began.

Failure: 1. To fall off the beam
2. Not to turn to right
3. Not to turn 360° on the beam
4. To replace left foot before 360° turn

Scoring Techniques

The subject is rated on a pass or fail basis; credit is given for stunts achieved. Scoring is as follows:

1 (beginning stunts passed) + 1.5 (intermediate stunts passed) + 2 (advanced stunts passed) = score

Perfect score: $5 \times 1.0 + 5 \times 1.5 + 4 \times 2.0 = 20.5$
APPENDIX G

Balance Beam Speed Tests

TEST I: RUN, FULL TURN

Directions:
1. The subject mounts the Olympic Balance Beam by means of a table exactly the height of the beam.
2. The subject began with both feet on the beam, either foot in front of the other, heel to toe position.
3. With the phrase "ready, go" the subject begins the task, and the examiner starts the stop watch.
4. The subject completes a full turn on the beam before descending onto tumbling mats positioned under the beam at the end.

Scoring:
1. Three trials allowed; total of three trials becomes score.
2. Trial terminated when last foot leaves beam for dismount.

TEST II: SLIDE, HALF TURN

Directions:
1. The subject mounts the Olympic Balance Beam by means of a table exactly the height of the beam.
2. The subject positions herself at the end of the beam, so that she leads with her side.
3. With the phrase "ready, go" the subject begins the task and the examiner starts the stopwatch.
4. When the subject reaches a midpoint on the beam, so indicated with a painted line, she executes a half turn and continues to slide to the end of the beam, where she dismounts by jumping onto the tumbling mats.

Scoring:
1. Three trials allowed; total of three trials becomes score.
2. Trial terminated when final foot leaves beam for dismount.
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Articles


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