THE RELATIONSHIP BETWEEN ANTERIOR-POSTERIOR AND LATERAL DYNAMIC BALANCE

by

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A THESIS

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THE RELATIONSHIP BETWEEN ANTERIOR-POSTERIOR AND LATERAL DYNAMIC BALANCE

A Thesis

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and Physical Education for Women

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by

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Purpose

The purpose of this study was to investigate dynamic balance and to ascertain relationships between dynamic anterior-posterior balance and dynamic lateral balance. The specific problem was to determine whether dynamic balance in an anterior-posterior direction is significantly related to dynamic balance in a lateral direction, or whether anterior-posterior balance and lateral balance are different and independent factors involved in the total function of dynamic balance.

Method

The methods used to examine the hypothesis set forth in this study included an investigation of related literature, a controlled experimental examination, and a statistical analysis.

The investigation of related literature included a thorough examination of pertinent studies in the area of balance. The controlled experimental examination included the administration of two dynamic balance tests to forty subjects. The data were obtained from the performance scores of the subjects. The statistical analysis included the use of coefficients of correlation, and the t-test for significant differences in the mean scores.

Findings

Within the limits and design of this study, the analysis of the data revealed the following major findings:

1. Although there was some relationship between dynamic anterior-posterior balance and dynamic lateral balance, the relationship was not great enough to be of predictive value.

2. An individual's ability to balance in a lateral direction was significantly superior to his ability to balance in an anterior-posterior direction.

Conclusion

Within the limitations of this study it was concluded that anterior-posterior balance and lateral balance are different and independent factors involved in the total function of dynamic balance.

Approved:

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Supervising Professor

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Chapter 1

INTRODUCTION

The human balance factor, the ability of the human body to adjust to external forces by maintaining or regaining equilibrium in respect to a desired body orientation, is both important and essential to successful motor performance. The ability to balance is recognized as one of the basic motor skills, and therefore is a vital aspect of skilled performance in sports, dance, and gymnastics. In fact, a sense of balance is fundamental to practically all human movement.

Balance has become an area of special interest to physical educators. Various authors (4, 17, 35, 66, 48, 8, 56, 75) in the field have associated balance with such attributes as motor ability, motor skill, motor coordination, motor educability, physical fitness, and kinesthesis. Many batteries of tests have been developed which presumably measure these components in an individual's motor make-up. Most of these tests include one or more items to assess balance ability, some of these items measuring static balance, others measuring dynamic balance.

Many of the widely employed measures of balance, both static and dynamic, appear to measure balance primarily in a forward-backward or anterior-posterior direction, while other tests appear to measure balance ability primarily in a sidewise or lateral direction. Although many studies have dealt with balance, many questions concerning this complex mechanism remain unanswered. Should the general factor of balance perhaps be broken down or divided into more basic abilities? Is the same factor being measured regardless of the primary direction or plane of movement, or is a different and independent sensori-motor function being measured? Is balance ability in one plane perhaps superior to balance ability in the other plane? Is an individual more sensitive and more responsive to an off balance situation or tilt in one direction than in the other direction? Such questions need to be answered.

STATEMENT OF THE PURPOSE

The purpose of this study was to investigate dynamic balance and to ascertain relationships between dynamic anterior-posterior balance and dynamic lateral balance.

STATEMENT OF THE PROBLEM

The specific problem of this study was to determine whether dynamic balance in an anterior-posterior direction is significantly related to dynamic balance in a lateral direction, or whether anterior-posterior balance and lateral balance are different and independent factors involved in the total function of dynamic balance.

HYPOTHESIS

It was hypothesized that there is a significant relationship between an individual's ability to balance in an anterior-posterior direction and in his ability to balance in a lateral direction, as measured by performance on a stabilometer.

IMPORTANCE OF THE STUDY

The importance of the study rests upon the need for further insight into the complexity of balance. In 1967, Cratty (5:121) commented that since numerous investigators consider balance to be a basic factor in perceptual motor ability, further investigation of this quality is imperative.

An examination of dynamic anterior-posterior balance and dynamic lateral balance would provide further insight into the complex human function of balance, and thus contribute to the existing knowledge concerning movement and the response of the individual as he attempts to move under various circumstances. Then perhaps the physical educator would have a better knowledge and understanding of the true nature of balance, the nature of currently accepted measures of balance, and the specific type of balance ability required by the various movement patterns essential to sports, dance, gymnastics, and daily living activities. Through such insight the factors involved in balance might be better identified and defined, and more appropriate tests might be devised which would more adequately separate and accurately measure the different balance factors. Further insight into balance would provide the physical educator with an important tool, not only for use in assessing balance ability, but also as a means for improving instructional techniques. In addition, it might offer supportive evidence for considering specific teaching and training in balance, as it relates to particular activities, as a more integral part of physical education programs.

SCOPE AND LIMITATIONS OF THE STUDY

This study was limited to specific subjects, a specific testing instrument, and two specific balance tests.

The subjects were forty college women students, ranging in age from eighteen to twenty-two years. They were enrolled in physical education service classes, and their participation in the study was on a voluntary basis. It was assumed that they were in good health and free from any handicap which might significantly alter their performance.

Several other assumptions were basic to the study: (1) that the performance scores yielded were reliable measures of dynamic anterior-posterior balance and dynamic lateral balance; (2) that the practice trial given for each test, before scores were recorded for evaluative purposes, was sufficient to enable the subject to become familiar with the testing apparatus and with the particular stance to be assumed during the test; (3) that the number of test trials given for each balance test was sufficient to yield a valid score; (4) that an adequate rest period was allowed between each test trial, and between the two different tests to control the fatigue factor; (5) that the use of an alternating testing method counterbalanced any fatigue or practice effects; and (6) that each subject was motivated to perform to the best of her ability on each test trial.

PROCEDURE

The following procedures were adhered to in the investigation of the problem: (1) The problem was selected and clarified after reviewing pertinent literature. (2) Criteria for selecting the testing apparatus and the balance tests were established, and the particular apparatus and specific tests were determined. (3) Forty college women, enrolled in physical education service classes at Sam Houston State University, Huntsville, Texas, volunteered to be subjects in the study. (4) The balance tests were administered to all subjects in the research laboratory in the physical education department at Sam Houston State University. (5) The performance scores of each subject constituted the data collected and used for analysis of balance ability. (6) The major analytical procedures employed in treatment of the data were correlation techniques. (7) The findings were interpreted and discussed, and a conclusion was drawn.

DEFINITION OF TERMS

The following terms are defined for clarification of their intended meanings as used in this study:

Dynamic balance. Dynamic balance is the ability of the subject to maintain or regain bodily equilibrium when exposed to an off balance situation on a moving platform.

Anterior-posterior balance. Anterior-posterior balance is the ability of the subject to maintain or regain equilibrium when exposed to an off balance situation in the sagittal plane or in a forward-backward direction.

Lateral balance. Lateral balance is the ability of the subject to maintain or regain bodily equilibrium when exposed to an off balance situation in the frontal plane or in a sidewise direction.

Sagittal plane. The sagittal plane is a vertical plane which passes through the body from front to back, dividing it in half. Movements occurring in this plane are flexion, extension, and hyperextension.

Lateral plane. The lateral plane is a vertical plane which passes through the body from side to side, dividing it in half. Movements occurring in this plane are abduction, adduction, and lateral flexion.

ORGANIZATION OF THE REMAINING CHAPTERS

Chapter 2 presents a selected review of literature in the general area of balance. In Chapter 3 is a description of the procedures, the subjects, the testing equipment, the balance tests, and the statistical design to be employed in the treatment of the data. An analysis and interpretation of the data is included in Chapter 4. The final chapter presents a summary, conclusion, and recommendations for further investigation in the study of dynamic balance.

Chapter 2

REVIEW OF LITERATURE

Many studies have been published concerning balance, although none have been directly or specifically related in either design or purpose to the present investigation. Therefore, the literature reviewed in this chapter has been selected because of its general relationship to the study.

The first section of the chapter includes a brief discussion of studies dealing with identification of the different types of balance. The second section presents a discussion of balance devices and tests which are commonly employed in measuring balance ability. The third section reviews studies pertaining to the relationship of balance to such variables as age, sex, height, weight, and vision. The final section discusses balance as it relates to attributes such as motor ability, motor skill, motor coordination, physical fitness, and kinesthesis.

COMPONENTS OF BALANCE

For the purpose of analysis balance is often divided into two related, although different processes, namely static equilibrium and dynamic equilibrium. Static balance is the ability to maintain equilibrium in a fixed position in relation to gravity, and requires continuous, tonic contractions of muscles. Dynamic balance is the ability to maintain equilibrium while in motion, and requires re-establishment of equilibrium after the body has been thrown off balance in relation to gravity. It involves a continuously changing activity pattern of the muscles, which disturbs the gross body orientation and requires further muscular activity to re-establish the orientation. The distinct nature of these two types of balance is indicated by the low correlation of .34 between measures of static and dynamic balance as obtained in a study by Bass (27). Another investigator, Travis (61), found no correlation between static and dynamic equilibrium as measured by the ataxiameter and stabilometer. The theory that balance is composed of static and dynamic components was further supported in a study by Drowatzky and Zuccato (33), who found no significant relationship between various selected measures of static and dynamic balance.

BALANCE DEVICES AND TESTS

Numerous methods and devices have been employed to determine an individual's ability to balance himself. The literature most frequently includes the following devices and tests for measuring static and dynamic balance: the stick test, the stepping stone test, the ataxiameter, the Johnson-Metheny canvas, rotary chairs, walking beams or rails, balance boards, stabilometers, and balance stunts.

Among the earlier tests devised were the Bass Stick Test (27) for measuring static balance, and the Bass Stepping Stone Test (27) for measuring dynamic balance. These two tests are still employed frequently in both balance studies and other studies concerned with human motor performance.

The Miles ataxiameter (44) has long been widely used to measure one aspect of static balance. This instrument measures body sway in both the lateral and anterior-posterior planes.

The Johnson-Metheny Test (50) was developed to measure dynamic balance in the form of front and back rolls and vertical turns in the air. Rotary chairs (44) have also been used frequently to measure the rotary aspect of dynamic balance.

Other tests which have been devised to measure dynamic balance include the Seashore Beam Walking Test (57) and a balance rail test developed by Cron and Pronko (30). There have been many modifications of the balance beam and the balance rail tests with respect to the width, length, and height of the balance rail or beam, and the method of performance and scoring. Espenschade and Eckert reported the following conclusion regarding walking boards:

> The walking board has . . . been used as a dynamic test of balance over a wider range than any other measure but even here the size of the board, the manner of scoring, and the general

> procedure differ to such an extent that comparison of results obtained by different investigators is not feasible. (7:134)

More difficult tests of dynamic balance involve the use of unstable platforms. The balance board (15, 67), and the balchronometer (70) and the dynabalometer (52), instruments similar to the balance board, all measure an individual's ability to balance on an unstable platform resting on an axis base. The stabilometer (60) measures ability to balance on a suspended platform.

Among the diversity of techniques and methods used to measure balance are balance stunts. The Brace Test (1) and the Iowa Revision of the Brace Test (47) consist of stunt-type skills, the majority of which are measures of static balance. These tests have been used in numerous investigations of balance and related motor performance studies.

FACTORS INFLUENCING BALANCE PERFORMANCE

An individual's balance is influenced by many factors. Studies pertaining to an investigation of some of these factors include the following:

Age. Beebee (28), in a study of the relationship between balance and nutrition in children, found that balance increases with age. The most rapid rise in balancing ability occurred in children aged six to eight.

In another study concerning the development of balance in school children, Cron and Pronko (30) found that ability to walk on a balance board improved with age, leveled off at about eleven years of age, and began to decline in the twelve to fifteen year old group. In a similar study, Seashore (57) reported comparable findings.

Glassow and Kruse (44) conducted a longitudinal study of the motor performance of girls aged six to fourteen years. The results showed that the performance scores, including performance of balance items, improved with age and grade level.

An interesting point regarding the variety of measures used to evaluate balance performance of different age groups is found in Espenschade and Eckert's book concerning motor development:

> . . . the complexity of balance and wide range of ability from one age level to another has resulted in very low intercorrelations of the various measures so that no single measure of balance can be considered to be useful for testing over a wide age range. (7: 133-134)

Sex. Beebee (28), investigating the relationship between balance and nutrition, found no sex differences in the ability of children to balance on the balance board. However, Cron and Pronko (30) found fluctuations regarding balance and sex. The girls averaged better than the boys in the four to eight year age group, but the boys surpassed the girls in the eight to fifteen year age group.

The physical growth and gross motor performance of children in grades one, two, and three was studied by Seils (58). The balance item used in this investigation was the balance stick test. Results of the study showed that mean performance scores of the boys increased noticeably each year. The mean performance scores of first and second grade girls was very similar, but the mean of third grade girls was twice as high as in the first two grades.

Balance is an important factor in many of the stunts included in the Brace Motor Ability Battery used in Espenschade's study (35) of motor coordination in ten to seventeen year old boys and girls. Findings showed that there were few sex differences in scores up to the age of fourteen, but after that age the boys excelled in performance.

Bachman (25) reported no significant sex differences in either the six to twenty-six year age range or the twenty-six to fifty year age range with respect to motor learning ability on a stabilometer. However, in another study involving stabilometer performance with the weight factor controlled, Travis (61) found a small sex difference in favor of college women over college men.

Height and weight. Using the Miles ataxiameter to study static balance, Fearing (38) found that height and weight were factors which had no significant relationship to static balance ability. Travis (61), likewise, found height and weight to have no bearing on static sway scores, or on rotational balance scores. In regard to dynamic stabilometer performance, weight was found to be of great importance, but height of little importance, as determined by controlling height and varying weight and vice versa.

Both Seils (58) and Seashore (57) found that height and weight were more highly correlated with balance during the ages of five to twelve than during the later years of thirteen to eighteen.

In a study previously mentioned by Espenschade (35), no relationship was found between dynamic balance, height, and weight.

Vision. Beebee's investigation (28) of balance in children included the vision factor. A marked loss in equilibrium was noted when vision was eliminated by blindfolding the subjects.

Travis (61) found that both static and dynamic balance performance were aided greatly when visual cues were present. Results also indicated that the finer the visual point of reference, the better the performance.

Edwards (34) studied static equilibrium and vision and reported that subjects performed significantly better with eyes open than with eyes closed. Visual fixation was also varied, but no significant difference was noted in body sway when subjects fixed their eyes on either a near or distant object.

Wapner and Witkin (62) also found visual factors to be related to balance. In a study of the maintenance of balance under varying conditions of the visual field, the results indicated that balance became progressively poorer as the visual field was weakened, eliminated, and finally made unstable.

BALANCE AS RELATED TO VARIOUS ASPECTS OF MOTOR PERFORMANCE

Balance has frequently been studied in regard to its role as a component of various aspects of an individual's motor make-up. Related investigations have dealt with motor ability, motor skill, motor educability, motor coordination, physical fitness, and kinesthesis.

Clarke's description of the components of motor ability has attained acceptance among some physical educators (4). It includes balance as one of the factors important in the performance of gross motor skills.

In 1954, Fleishman (39) isolated and defined important dimensions of psychomotor ability which provide a functional classification of abilities that account for individual differences in performance. Balance was found to be one of the many components contributing to more complex motor abilities.

In a study of static balance and motor ability, Estep (37) reported a positive relationship between static equilibrium and ability in gross motor activities.

Breitenbach (65) investigated athletic ability and dynamic balance. The results of this study indicated that no significant relationship existed between dynamic balance and athletic ability of high school boys.

Studies by Mumby (51) and Gross and Thompson (42) dealt with the relationship of balance to motor ability in specific activities. Mumby, investigating wrestling ability and stabilometer performance, found that good wrestlers were somewhat better than poor wrestlers in their ability to balance. Gross and Thompson used the Bass Test for measuring dynamic balance ability of swimmers. The findings showed that the subjects with better balance could swim faster and had better swimming ability than those subjects with poorer balance.

Espenschade, Dable, and Schoendube (36) investigated dynamic balance in adolescent boys. The results of this study showed that dynamic balance correlated substantially with physical or motor abilities important in the physical education program.

In a study comparing the balance of college athletes and average college students, Lessl found that the athletes performed significantly better. On the basis of this study, Lessl concluded that "there is no evidence to dispute the assumption that balance is a fundamental skill in physical education activities." (70)

Phillips (53) examined a group of physical education tests recommended for use with girls in an attempt to isolate the traits or factors common to these tests. A balance factor was evident, indicating that balance was considered an important aspect of physical education.

The consideration that balance is one of the fundamental skills in physical education activities is also supported by Schurr:

> Stability is an important factor in all movement skills. Depending on the action involved, one may wish to maintain balance, upset balance in order to move quickly, or regain balance. A stable position is also important for the production of force. (17:150)

The literature revealed few studies concerning motor educability, indicating that this is an area in which research is lacking. However, investigations by Gross, Griesel, and Stull (43) and Gire and Espenschade (40) included balance tasks among the test items used to measure motor educability.

McCloy (48) employed the factor analysis technique in studying motor educability tests. Body balance was identified as one of the primary factors involved in motor educability.

The consideration that balance is a factor involved in motor coordination has been indicated by the use of balance items in several studies dealing with motor coordination.

Espenschade (35) studied the development of motor coordination in boys and girls. Dynamic balance was especially important in the performance of many of the items included in the Brace Test, which was the instrument used in this study.

Cumbee (31, 66) and Cumbee, Meyer, and Peterson (32) have applied the factor analysis method in studies of motor coordination of college women, and third and fourth grade girls. In both studies body balance was among the factors distinguished from twenty-one variables of coordination.

As early as 1924, balance was considered an aspect of physical fitness. In a study concerned with measuring organic and neuromuscular fitness, Collins and Howe (10) employed the use of a balance board type apparatus to determine the balance aspect of fitness.

Fleishman (8) presented a critical review and integration of previous factor analysis studies in the area of physical fitness. The balance area was included among the range of physical fitness factors which have been identified.

Balance is considered an important aspect of kinesthesis, and tests of balance are recommended for inclusion in any battery of kinesthetic tests (18:75). A number of physical educators interested in kinesthesis have devised such test batteries, notably Scott (56), Young (64), and Wiebe (63).

In another investigation Wiebe (75) used the factorial analysis technique in studying a battery of tests designed to measure kinesthesis. Russel (73) and Magruder (71) also investigated kinesthesis in terms of analyzing the components which contribute to this complex function. In each case, balance has been identified among the components involved in kinesthesis.

SUMMARY

This chapter presented a review of literature in the general area of balance. The selected investigations and reviews dealt with identification of static and dynamic balance, balancing devices and tests employed for measuring balance ability, factors influencing balance performance, and balance as it relates to various aspects of motor performance.

Chapter 3

EXPERIMENTAL DESIGN AND PROCEDURE

The purpose of this study was to examine dynamic balance and to determine the relationship between dynamic anterior-posterior balance and dynamic lateral balance. In order to accomplish this purpose, two specific dynamic balance tests were selected and administered to forty college women, all of whom were enrolled in physical education service classes at Sam Houston State University, Huntsville, Texas. The data collected during the testing situation were then analyzed statistically and empirically.

This chapter describes: (1) the testing apparatus, (2) the balance tests, (3) the subjects, (4) the specific testing procedures, and (5) the techniques utilized in treating the data.

THE TESTING APPARATUS AND THE BALANCE TESTS

Criteria for Selection of the Testing Apparatus

The following criteria were used for selection of the testing apparatus:

1. The apparatus must be novel to the subjects.

2. The apparatus should yield high performance reliability as shown in preceding related studies.

3. The apparatus must be conducive to measuring balance both in an anterior-posterior direction and in a lateral direction.

Criteria for Selection of the Balance Tests

The criteria established for selection of the balance tests included:

1. The balance tests must measure dynamic anterior-posterior balance and dynamic lateral balance.

2. The balance tests must be such that balance ability can be ascertained by the measurement of individual trials.

3. The apparatus must yield an objective score indicative of balance performance.

4. The balance tests must be administratively feasible.

Selection and Description of the Testing Apparatus

Apparatus selection. The stabilometer, the apparatus used in this study, was apparently first used in 1944 by Travis (60, 61). He designed a stabilometer and used this device in an investigation of various behavioral aspects of postural balance and body orientation. Since that time, many other investigators have used modifications of the stabilometer in a variety of studies. These have included investigations by: Mumby (51), Bachman (24, 25, 26), Ryan (54, 55), Singer (59), Rice (72), and Fox (68). The stabilometer used in the present study was identical to the one used by Rice, except for very minor modifications. The stabilometer provides a measure of dynamic balance on a moving platform.

Apparatus description. The stabilometer consisted of a forty-one inch by twenty-one inch balance platform suspended from two pivot axis rods (two one-inch pipes) mounted six inches above the balance platform. The balance platform was attached by means of the two pivot axis rods to two triangular supports at a height of fifteen inches from the base on which the supports were mounted. When the balance platform was tilted downward three inches in either direction, it hit a micro-switch attached to each side of the base. A one-hundredth second timer was connected to the micro-switches, and when the balance platform tipped downward three inches in either direction, it contacted the micro-switches and stopped the clock. The clock recorded only the amount of time the subject was on balance. Another clock was used to measure the thirty-second time limit for each trial. The thirty-second timer was started with the first movement of the balance platform from the base. Photographs of a subject performing the two balance tests on the stabilometer appear in Plates I and II on pages 23 and 25 respectively.

PLATE I

SUBJECT PERFORMING ANTERIOR-POSTERIOR

BALANCE TEST

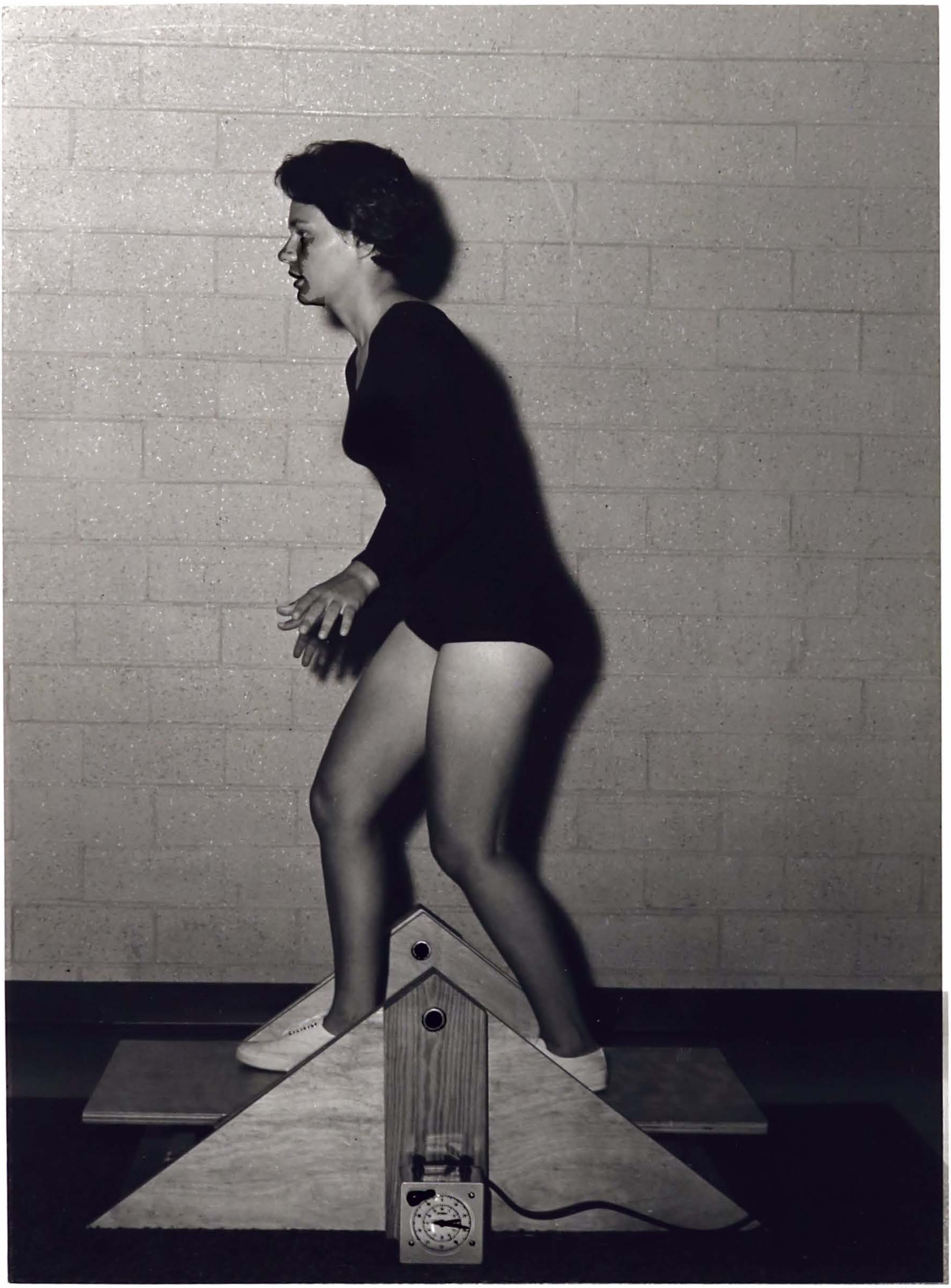

PLATE II

SUBJECT PERFORMING LATERAL

BALANCE TEST

SELECTION OF THE SUBJECTS

Forty undergraduate college women between the ages of eighteen and twenty-two years participated as subjects in this study. The subjects were obtained on a voluntary basis from students enrolled in physical education service classes during the 1969 Spring semester at Sam Houston State University, Huntsville, Texas. Since the subjects had been medically approved for non-restrictive physical education classes, they were assumed to be in good health and free from any restricting conditions which might alter their performance. None of the subjects had ever participated in a balance study nor had had previous experience on the stabilometer or a similar device. Leotards and tennis shoes were worn by all subjects for the purpose of uniformity in testing.

TESTING PROCEDURE

Design and administration. Prior to the actual investigation, several students who were not involved in the study were tested on the stabilometer. At this time the specific testing procedures, and test administration and organization were established.

For safety purposes, the stabilometer was placed on a mat in a large clear area of the testing room. A chair was placed nearby for the subject to sit in during the rest periods. Each subject was tested individually and in isolation from other subjects. Only the investigator, who administered the balance tests to each subject, was present during the testing period.

Prior to administering the first of the two balance tests for evaluative purposes, each subject was given one thirty-second practice trial. This practice trial enabled the subject to become familiar with the stabilometer and with the particular stance to be assumed during the test. Before the practice trial, the balance test was explained and demonstrated by the investigator, and any question the subject had concerning the test was answered. Following the practice trial, the subject had a thirty-second rest period before beginning the three test trials which would be recorded for evaluative purposes.

On the first balance test each subject was given three thirty-second trials with a thirty-second rest period between each trial. Following the third trial on the first balance test, each subject was given a five minute rest period during which time the second balance test was explained and demonstrated by the investigator. Any question which the subject had concerning the test was answered. After the five minute rest period the subject was given a thirty-second practice trial on the second balance test, followed by a thirty-second rest. Then the subject performed three thirty-second trials on the second balance test with a thirty-second rest period between each trial. The performance scores of each subject were recorded for the three trials on the first balance test and the three trials on the second balance test.

Throughout the investigation, an alternating testing method was used to counter-balance any fatigue or practice effects. The first subject was administered the anterior-posterior balance test trials first, and the second subject was administered the lateral balance test trials first. This alternating procedure was continued for all forty subjects. By using this method, twenty of the subjects performed the anterior-posterior balance test trials first followed by the lateral balance test trials, while the other twenty subjects performed the lateral balance test trials first followed by the anterior-posterior balance test trials.

The anterior-posterior balance test was performed by standing lengthwise on the platform in a forward stride position, thereby testing the subject's ability to maintain balance when exposed to an off balance situation in a forward-backward direction or in the sagittal plane. The lateral balance test was performed by standing sidewards to the length of the platform in a side stride position, thereby testing the subject's ability to maintain balance when exposed to an off balance situation in a sidewise direction or in the frontal plane. During both the anterior-posterior balance test and the lateral balance test the subject attempted to maintain a balanced position, that is to keep the platform as parallel to the base as possible for as long and as often as possible, during each thirty-second trial. The performance score, the time the subject was on balance, was recorded for each test trial to the nearest one-hundredth of a second. Subjects were instructed to perform each trial to the best of their ability, and were informed of their scores following each trial.

Instructions. The investigator demonstrated the balance tests and gave the following instructions:

> I am going to explain and demonstrate the test which you will take, and then you may ask any questions which you might have concerning the test. This device is called a stabilometer and it is used to measure balance ability. You will place one foot on one end of the platform and the other foot on the other end, so that you are standing in a side stride position facing the wall across the room. This is the starting position. When I give the signal, 'Begin,' you will attempt to balance the platform, as I am trying to do, so that it does not tip down and touch the boards underneath either end. In other words, you try to keep the platform balanced by keeping it as parallel to the base or floor as possible. You do not want it to tip down and hit the boards underneath. You will attempt to balance the platform for as long as you can during thirty seconds. When I give the signal, 'Stop,' you will get off the platform and sit in this chair for a brief rest period until it is time for the next trial, and during this time you may experiment with finding a comfortable side stride position. Take the position in which you think you can balance the best, but be sure to keep your feet in a side stride position and keep your body facing toward the wall across the room. After the practice trial you will sit in the chair and rest for thirty seconds. Then you will perform three more test trials for thirty seconds each, with a thirty

second rest between each trial. Following this you will sit and rest for five minutes while I demonstrate and explain the next test. I have two clocks, one to measure the thirty-second time limit for each trial, and one to measure the amount of time you are actually balanced. Any time you let the balance platform tip down and touch the board underneath either end, it hits a micro-switch which is attached to these boards, and this stops the clock which is connected to them. Since it stops the clock anytime it tips down and hits these switches, the clock will only record the amount of time you are on balance. After each trial I will tell you your score. In other words, I will tell you how many seconds you kept the platform balanced during each thirty-second trial. Please try to balance to the best of your ability on all of the trials. Do you have any questions? Now you may take your practice trial.

After completion of the first balance test trials the second balance test was demonstrated and explained. The following instructions were given:

You have five minutes to rest now, and while you are resting I will show you the next test. This time you are going to stand lengthwise on the platform. You will place either foot you wish forward on one end of the platform, and the other foot on the other end, so that you are standing in a forward stride position, facing the windows across the room. Again, you will attempt to balance the platform, as I am trying to do, so that it does not tip down and hit the boards underneath either end. You will have a practice trial, as you did on the first test, and during this time you may experiment with finding a comfortable forward stride position. Take the position in which you think you can balance the best, but be sure to keep your feet in a forward stride position, meaning one foot ahead of the other foot, and to keep your body facing directly toward the windows. After the practice trial you will rest for thirty seconds, and then you will take three more test trials with rest periods in between, just as you did on the first test. I will give you the same signals to begin and to stop as I gave before, and will tell you your score after each trial. Again, please try to balance to the best of your ability on every trial. Do you have any questions concerning this test? Now you may take your practice trial.

Since an alternating testing method was used, the order of the preceding instructions was reversed for every other subject.

TREATMENT OF THE DATA

The object in analyzing the data was to determine if a significant relationship existed between an individual's ability to balance in an anterior-posterior direction and his ability to balance in a lateral direction. The statistical device which measures or expresses relationship is correlation. The Pearson product-moment coefficient of correlation was used to determine the relationship existing between the two balance tests.

An additional objective in analyzing the data was to determine if an individual's ability to balance in one plane was significantly superior to his ability to balance in the other plane. This analysis was made by an examination of the means of the two tests by using the t-test of significance of mean differences.

The facilities of the Data Processing Center at Sam Houston State University were used to compute the data. The statistical techniques used in the study were programmed for the computer according to the procedure explained in

Guilford (11).

SUMMARY

This chapter described the experimental design and procedures used in the investigation. Included was a discussion of: (1) selection and description of the testing apparatus, (2) selection of the balance tests, (3) selection of the subjects, (4) description of the testing procedures employed, and (5) description of the techniques used in treatment of the data.

Chapter 4

ANALYSIS AND INTERPRETATION OF THE DATA

In order to examine dynamic anterior-posterior balance and dynamic lateral balance, a statistical analysis was included. Performance scores were used to establish reliabilities of the two balance tests, to determine the relationship between anterior-posterior balance and lateral balance, and to determine if an individual's ability to balance in one direction is superior to his ability to balance in the other direction.

This chapter includes a presentation of the data, a discussion of the findings of the study, and an interpretation of the significance of the findings.

RELIABILITIES OF THE TWO BALANCE TESTS

Reliabilities for the anterior-posterior dynamic balance test and the lateral dynamic balance test were determined by computing the reliability coefficients of correlation for each test. The correlation technique employed was the Pearson product-moment coefficient of correlation, with the correlation being computed between the first trial and the third trial of each of the two balance tests. The reliability coefficient for the anterior-posterior dynamic balance test was found to be .62, and the reliability coefficient for the lateral dynamic balance test was found to be .77. When the Spearman-Brown prophecy formula was applied, the reliability coefficient for the anterior-posterior balance test increased to .83, and the reliability coefficient for the lateral balance test increased to .91. The data related to test reliability are found in Table I on page 36.

These reliability coefficients are possibly not as high as one might expect to find. Several factors may have influenced these findings. Since the balance tests and the testing instrument were novel to the subjects, perhaps the learning factor affected the performance scores, and in turn the reliability coefficients.

The reported test reliabilities were computed on the first and third trials, which were the beginning scores of individual performance. These first trials represent the beginning aspects of a total learning range. If the reliabilities had been computed over many trials, with a total range of scores, the reliability coefficients possibly would have presented what might approach a more normal scattergram.

ANTERIOR-POSTERIOR BALANCE AND LATERAL BALANCE RELATIONSHIPS

The relationship between dynamic anterior-posterior balance and dynamic lateral balance was determined by computing the coefficient of correlation between the anterior-posterior balance test scores and the lateral balance test scores.

TABLE I

DATA RELATED TO TEST RELIABILITY BASED ON TRIAL 1 VS. TRIAL 3 OF THE ANTERIOR-POSTERIOR AND LATERAL BALANCE TESTS

Test	Mean Trial 1	Mean Trial 3	Standard Deviation Trial 1	Standard Deviation Trial 3	$r_{1,3}$	Spearman-Brown $r_{1,3}$
Anterior-Posterior	16.84	18.45	2.83	3.07	.62	.83
Lateral	19.57	22.30	4.51	4.58	.77	.91

The Pearson product-moment coefficient of correlation was the statistical procedure employed. A correlation coefficient indicates some degree of relationship between anterior-posterior balance and lateral balance. When the coefficient was subjected to a test for significance, the null hypothesis of chance relationship was rejected at the .01 level of confidence. The data are presented in Table II on page 38.

In order to evaluate and interpret the effectiveness of the obtained correlation with respect to predictive value, a coefficient of alienation and a coefficient of forecasting efficiency were determined. The coefficient of forecasting efficiency was found to be .22, thus indicating that the forecasting efficiency of the obtained coefficient is only 22 percent better than chance prediction, and that the correlation has a low or minimum predictive value. The findings obtained from determining the coefficient of correlation and subjecting this coefficient to predictive equations indicate that although anterior-posterior balance and lateral balance appear to be related, the relationship is not great enough to assure accuracy in forecasting or predicting one variable from the other.

The obtained coefficient of correlation does not indicate that anterior-posterior balance and lateral balance are one and the same factor, or that performance scores on one balance test can be predicted with any degree of accuracy from knowledge of the scores obtained on the other balance test. It can be assumed, therefore, that anterior-posterior

TABLE II

COEFFICIENTS INDICATING THE RELATIONSHIP BETWEEN THE ANTERIOR-POSTERIOR AND LATERAL BALANCE TESTS

Coefficient of Correlation*	Coefficient of Alienation	Coefficient of Forecasting Efficiency
.62	.78	.22

*With 38 degrees of freedom, an r of .31 was significant at the .05 level of confidence and an r of .40 was significant at the .01 level of confidence (Table V. A. of Fisher. Statistical Methods for Research Workers) balance and lateral balance are to some extent different and independent balance factors. These findings seem to indicate that in order to provide a more accurate assessment of an individual's motor make-up, a battery of tests should include balance items that measure balance both in an anterior-posterior direction and in a lateral direction.

MEAN DIFFERENCES OF THE ANTERIOR-POSTERIOR AND LATERAL BALANCE TESTS

The means of the two balance tests were submitted to the t-test of significance of mean differences in an attempt to determine if an individual's ability to balance in one direction was superior to his ability to balance in the other direction. The difference between the means was found to be highly significant at the .01 level of confidence. The data are presented in Table III, page 40.

These findings indicate that an individual's ability to balance in a lateral direction is significantly superior to his ability to balance in an anterior-posterior direction. Perhaps an individual is more sensitive and responds more quickly to an off balance situation in a lateral direction than in an anterior-posterior direction.

This assumption has been supported by comparable findings in studies of static equilibrium as related to body sway in the standing or upright position. Fearing (38), Bass (27), and Travis (61) found that individuals are more

TABLE III

DIFFERENCE IN THE MEAN SCORES OF THE ANTERIOR-POSTERIOR AND LATERAL BALANCE TESTS

Test	Mean	Standard Deviation	Standard Error of Means	Value of t*
Anterior-Posterior	52.83	7.96	2.02	
				6.40
Lateral	63.01	12.60	1.27	

*With 39 degrees of freedom, the value of t was found to be 2.04 at the .05 level of confidence, and 2.73 at the .01 level of confidence (Table I.V. of Fisher. Statistical Methods for Research Workers) sensitive to tilt in the lateral or frontal plane than to tilt in the sagittal or anterior-posterior plane. In other words, body sway was found to be greater in an anterior-posterior direction than in a lateral direction.

There are a number of factors which possibly contribute to these findings. The human body is constructed in such a way that it is more symmetrical laterally than it is anterior-posteriorly, and thus would appear to lend itself to greater lateral stability. It seems easier to keep the center of gravity of the body over the base of support in a lateral stride position than in a forward stride position. This might be attributed to the angle of the femurs in the acetabulum. When one stands in a lateral stride position the femurs are essentially in the anatomical position, thus providing good support and joint stability; but when one stands in a forward stride position the femurs are not fixed in as secure a position in the acetabulums. In a forward stride position all the joints of the lower extremities are probably placed in a less advantageous position for stability than in a lateral stride position where the joints are better approximated for bearing the body's weight.

Since a lateral stride position is the customary or habitual stance assumed when standing, individuals have had more practice and are more familiar with maintaining balance in this position than in a forward stride position. Even though the individual's normal pattern of locomotion, walking, requires a forward stride stance, this position is never really held or maintained. It is a constant losing and regaining of balance, maintained primarily because of the physical laws of inertia and momentum.

In the normal growth and developmental processes of the body, bilaterally symmetrical movements are the first neuromotor learnings. An infant's first movements are total symmetrical patterns involving the organism as a whole. When a child begins to learn to walk, he does so in more of a side-to-side or lateral movement pattern than in a forward pattern. He is also more prone to fall forward or backward than to fall toward the side or laterally. This again supports the theory that the body structure favors lateral stability, and that early motor learnings are bilaterally symmetrical.

Since the subjects had not previously experienced the balance tasks used in this study, they were confronted with a new and unlearned situation. In meeting such a situation, perhaps one unconsciously resorts back to the first, longer established neuromuscular patterns of symmetrical movements.

Another factor which possibly contributed to the findings was the involvement of the upper extremities. The use of the arms in balancing laterally is similar to the child's early movement patterns. When balancing in a forward stride position perhaps the arms were not used as effectively to assist balance because this required the more complex pattern of opposition.

The role that the eyes play in balance which involves motion sideways as opposed to balance which involves motion forward and backward may also have some bearing on the findings, as suggested in McCloy's study (48) of factors involved in the functions of balance.

SUMMARY

This chapter included a discussion of the findings of the study. The relationship between the two balance tests and the differences between the means of the two tests were examined carefully. Factors which might have influenced the outcomes of the study were presented and discussed.

Chapter 5

SUMMARY, FINDINGS, AND CONCLUSION

The purpose of this study was to investigate the relationship between dynamic anterior-posterior balance and dynamic lateral balance, as measured by performance on a stabilometer.

Forty women students enrolled in physical education service classes at Sam Houston State University volunteered to participate as subjects in the study. Each subject was administered three test trials on the anterior-posterior balance test and three test trials on the lateral balance test, with rest periods between each trial. Performance scores on each trial were recorded.

A Pearson product-moment coefficient of correlation was used to determine the relationship between anterior-posterior balance and lateral balance. The means of the two balance tests were submitted to the t-test of significance of mean differences to determine if an individual's ability to balance in one direction was superior to his ability to balance in the other direction.

MAJOR FINDINGS

The analysis of the data revealed the following major findings:

1. Although there was some relationship between dynamic anterior-posterior balance and dynamic lateral balance, the relationship was not great enough to be of predictive value.

2. An individual's ability to balance in a lateral direction was significantly superior to his ability to balance in an anterior-posterior direction.

CONCLUSION

Within the limits and design of this study, it was concluded that dynamic anterior-posterior balance and dynamic lateral balance are different and independent balance factors. Therefore, the hypothesis that there is a significant relationship between an individual's ability to balance in an anterior-posterior direction and in his ability to balance in a lateral direction, as measured by performance on a stabilometer, is found to be untenable.

RECOMMENDATIONS

The following recommendations are made for further investigation in the study of anterior-posterior balance and lateral balance:

1. Conduct a similar study using static balance tests instead of dynamic balance tests to measure anterior-posterior and lateral balance.

2. Conduct a study on dynamic anterior-posterior and lateral balance using a balance measure which requires the subject to move his entire body through space, rather than a measure which requires body adjustment on a moving platform.

3. Conduct a study comparing various methods of measuring dynamic anterior-posterior balance and dynamic lateral balance.

4. Conduct a similar investigation which includes a study of eye focus, foot positions, and somatotypes.

5. Conduct a study to compare an individual's ability to balance in an anterior-posterior direction and in a lateral direction with his ability to balance in both directions simultaneously.

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APPENDIX

APPENDIX

INDIVIDUAL SCORES ON THE ANTERIOR-POSTERIOR (X) AND LATERAL (Y) BALANCE TESTS

Subject	Test	Trials	Sum	Mean	Difference Between Means
1	X	16.60 19.72 20.10	56.42	18.80	3.21
	Y	19.19 21.99 24.86	66.04	22.01	
2	X	14.45 16.03 14.37	44.85	14.95	1.4
	Y	16.16 15.84 17.05	49.05	16.35	
3	X	13.10 15.49 17.91	46.50	15.50	10.28
	Y	25.14 25.79 26.41	77.34	25.78	
4	X	12.09 13.21 12.46	37.76	12.59	3.11
	Y	13.24 16.75 17.12	47.11	15.70	
5	X	11.84 15.18 13.09	40.11	13.37	.36
	Y	13.25 12.88 12.92	39.05	13.01	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
6	X	12.36 12.92 15.39	40.67	13.55	3.22
	Y	16.93 17.97 15.41	50.31	16.77	
7	X	16.95 14.92 15.09	46.96	15.65	4.36
	Y	22.73 19.03 18.00	59.76	19.92	
8	X	16.66 18.97 19.37	55.00	18.33	4.77
	Y	19.67 24.41 25.24	69.32	23.10	
9	X	21.25 19.27 18.90	59.42	19.80	1.96
	Y	14.97 18.84 19.72	53.53	17.84	
10	X	20.82 16.96 20.52	58.30	19.43	.20
	Y	15.83 19.35 22.53	57.71	19.23	
11	X	18.16 19.77 21.61	59.54	19.84	5.28
	Y	24.20 26.25 24.91	75.36	25.12	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
12	X	17.73 14.85 18.27	50.85	16.95	8.11
	Y	21.91 24.99 28.28	75.18	25.06	
13	X	16.62 14.37 15.05	46.04	15.34	.21
	Y	11.36 16.31 17.72	45.39	15.13	
14	X	18.16 21.80 21.03	60.99	20.33	.43
	Y	19.61 20.57 19.54	59.72	19.90	
15	X	13.58 10.90 17.40	41.88	13.96	2.79
	Y	10.67 10.35 12.51	33.53	11.17	
16	X	16.27 12.68 16.58	45.53	15.17	7.3
	Y	21.83 21.39 24.20	67.42	22.47	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
17	X	14.58 15.43 16.88	46.89	15.63	9.51
	Y	24.73 24.93 25.77	75.43	25.14	
18	X	17.81 15.49 14.33	47.63	15.87	6.48
	Y	19.67 20.68 26.71	67.06	22.35	
19	X	18.77 19.75 19.39	57.91	19.30	6.36
	Y	22.45 27.08 27.47	77.00	25.66	
20	X	18.11 19.51 21.84	59.46	19.82	2.35
	Y	20.66 20.34 25.51	66.51	22.17	
21	X	17.39 19.37 17.05	53.81	17.93	1.67
	Y	16.69 21.37 20.76	58.82	19.60	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
22	X	19.42 19.96 25.34	64.72	21.57	4.01
	Y	21.61 27.22 27.93	76.76	25.58	
23	X	22.81 23.94 21.03	67.78	22.59	7.07
	Y	29.77 29.46 29.75	88.98	29.66	
24	X	19.03 19.45 20.21	58.69	19.56	4.46
	Y	17.74 28.23 26.11	72.08	24.02	
25	X	12.95 13.51 13.56	40.02	13.34	3.05
	Y	11.91 16.45 20.81	49.17	16.39	
26	X	11.36 12.45 13.86	37.67	12.55	5.69
	Y	15.50 18.41 20.81	54.72	18.24	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
27	X	17.40 16.13 19.09	52.62	17.54	7.22
	Y	24.61 23.98 25.69	74.28	24.76	
28	X	21.20 18.61 21.32	61.13	20.37	1.66
	Y	23.25 21.74 21.11	66.10	22.03	
29	X	18.03 19.97 20.65	58.65	19.55	6.24
	Y	25.54 25.25 26.59	77.38	25.79	
30	X	17.69 20.96 18.62	57.27	19.09	8.61
	Y	28.10 25.83 29.17	83.10	27.70	
31	X	16.03 19.27 21.07	56.37	18.79	1.76
	Y	18.84 20.16 22.65	61.65	20.55	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
32	X	15.34 16.12 18.25	49.71	16.57	1.27
	Y	15.85 12.65 17.40	45.90	15.30	
33	X	17.10 19.51 17.19	53.71	17.90	.87
	Y	17.18 19.55 19.58	56.31	18.77	
34	X	14.18 14.68 16.81	45.67	15.52	1.16
	Y	17.18 18.51 14.35	50.04	16.68	
35	X	16.81 18.25 22.65	57.71	19.23	3.35
	Y	22.76 20.59 24.39	67.74	22.58	
36	X	15.66 22.55 22.07	60.28	20.09	.89
	Y	18.77 19.35 19.48	57.60	19.20	

APPENDIX (continued)

Subject	Test	Trials	Sum	Mean	Difference Between Means
37	X	16.18 16.28 18.56	51.02	17.00	3.63
	Y	21.00 20.15 20.75	61.90	20.63	
38	X	17.08 21.41 20.11	58.60	19.53	.52
	Y	18.53 20.16 21.48	60.17	20.05	
39	X	22.40 21.37 17.05	60.82	20.27	7.01
	Y	24.20 29.61 28.05	81.86	27.28	
40	X	19.61 20.89 23.77	64.27	21.42	.13
	Y	19.46 21.11 23.32	63.89	21.29	

Vita was removed during scanning