A STUDY OF THE EFFECTS OF FATIGUE, AS INDUCED BY THE HARVARD STEP TEST, ON KINESTHETIC PERCEPTION

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CHAPTER I

INTRODUCTION

Automation has brought more leisure time and many jobs that might be classified as sedentary in nature. Many people who have these easy jobs or a great amount of leisure time realize that they need some type of physical activity in order to maintain a healthy body. In the past few years, due to the impetus of the President's physical fitness council, emphasis has been placed on physical fitness in some schools and organizations; however, when an individual leaves school he often discovers it is difficult to strive continually to maintain a certain level of physical fitness on his own. One goal of physical fitness programs is to improve the individual's ability to meet and cope with the stress and demands of life with the problem of fatigue and its effect on physical performance. Various means are used for attaining this goal.

Coaches and physical educators are very much concerned with fatigue and kinesthesis, and they are continuously researching the possible psychological and physiological aspects of each. Although many studies have investigated muscular endurance in man by measuring sustained or repeated contraction, marching, running, tread-mill exercise,

etc., the exact nature of fatigue remains obscure. Fatigue affects performance and is experienced by everyone. The coach and physical educator must be alert to the function of fatigue as a danger signal warning of impairment, and in planning a physical education program he must take into consideration the limits of individuals and teams. Fatigue generally decreases kinesthetic sensitivity (21).

Kinesthesis is often referred to as the muscle sense or the motor sense. Oxendine (13) notes that there is considerable agreement regarding the general meaning of kinesthesis: (1) positioning of body segments, (2) precision of movement, (3) balance, and (4) space orientation. The kinesthetic sense has popularly been called the sixth sense because it was the first recognized addition to the original five senses. The kinesthetic sense, unlike the other five senses which require external impulses, is dependent upon internal stimulation.

For effective coordination of a motor act to take place there must be constant sensory stimuli set up by the act itself which "feed back" the results of movement and produce correction in the nervous system. The "feed back" of sensory information about movement and body position is called proprioception. Receptors for proprioception, which are widely distributed throughout the body, may be classified as vestibular and kinesthetic. Both are important and perform essential roles in the accomplishment of skillful performance.

The vestibular receptors are found in the nonauditory labyrinths of the inner ear. Each of these labyrinths, located on each side in the temporal bone of the skull, consists of a small chamber, the vestibule, which communicates with three small canals known as semi-circular canals. The vestibular receptors provide data regarding rotational acceleration or deceleration of movement, as in twisting or tumbling, and provides data that informs us of our posture in space (4, p. 37).

Kinesthetic sense receptors include the muscle spindles, Golgi tendon organs, and the pacinian corpuscles, and each contributes to kinesthetic or muscle sense, which enables man to perceive. The muscle spindles are widely distributed throughout muscle tissue. The motor response of the spindles is called a "stretch" or "myotic reflex" and is typefied by the tendon jerk elicited by a physician when he checks the patellar tendon reflex. The Golgi tendon is found in the musculotendinous junction. This ending is deformed by tension in the tendon, whether by stretching or by active contraction of the muscle, and discharges under both conditions, whereas the spindle discharges only when stretched (4, p. 40). The pacinian corpuscles are found concentrated in the fasciae, tendon sheaths, ligaments, joint capsules, and articular cartilages. They are stimulated by the deformation of deep pressure, and are possibly more important than spindles and tendon organs in detecting passive movement of position of a body segment in space (4, p. 41).

Statement of the Problem

The problem under study was the effects of fatigue, as induced by the Harvard Step Test, on kinesthetic perception.

Definition of Terms

The following terms and their definitions were used in the study:

1. Fatigue--that state following a period of mental or body activity characterized by a lessened capacity for work and reduced efficiency of accomplishment.

2. Kinesthetic perception--the term given to the sensation by which one is aware of position and movement of the total body or its segments.

3. Harvard Step Test--a test in which the subject steps up and down thirty times a minute on a twenty-inch bench for five minutes, unless he stops from exhaustion before then; then the subject's pulse rate is counted from one to one and one-half, two to two and one-half, and three to three and one-half minutes after stepping ceases, and the results mathematically formulated rate the physical fitness of the subject. In this study the subject must begin the exercise and continue until he stops from exhaustion or until fifteen seconds after he falls behind the cadence.

Purpose of the Study

The purpose of the study was to ascertain the effects of induced fatigue on performance of the balance, lengthwise test, the leg raise test, the vertical space test, and the separate feet test.

Limitations of the Study

The study was limited to sixty-one men physical education students at North Texas State University, Fall Semester 1968.

Description of Tests

The data used were the scores of subjects on each of four kinesthetic tests given before fatigue and immediately after fatiguing. These tests included

A. Separate Feet--Feet separated, heels are twelve inches apart.

a. Apparatus--Tapemeasure, blindfold, and chalk.

b. Technique--Subject is asked to stand errect with the heels touching. He is then instructed to separate his heels so that the inside of the heels are twelve inches apart.

c. Scoring--Deviation from the preferred score is recorded to the nearest one-fourth inch. Score is the total of three trials.

B. Vertical Space--Pointing to a designated point on yard stick.

a. Apparatus--Yardstick, blindfold.

b. Technique--The yardstick is placed vertically before the seated subject. He is instructed to look at the sixteen-inch mark and sense its position. Subject is then blindfolded and instructed to point to the preferred position. No practice trials are allowed.

c. Scoring--Deviation from the preferred score is recorded to the nearest one-fourth inch. Score is the total of three trials.

C. Balance, Lengthwise--A test of static balance.

a. Apparatus--Bass balancing stick, stopwatch, and blindfold.

b. Technique--Subject is instructed to place his dominant foot lengthwise on the balance stick, raise his other foot from the floor and see how long he can maintain his balance without touching his free foot or any part of his body to the floor. He is given one preliminary trial and then blindfolded for the test.

c. Scoring--Seconds are recorded to the nearest one-half second. Score is the total of three attempts.

D. Leg Raise--Leg raise to a designated angle.

a. Apparatus--Goniometer and two life-size stick figure drawings.

b. Technique--Subject is asked to lie on his non-dominant side and is shown a stick figure drawing with its leg raised at a 20° angle. He is then instructed to duplicate the angle seen.

c. Scoring--Deviation from 20° is recorded in degrees. Score is the total of three trials.

Survey of Previous Studies

The term "fatigue", used quite frequently and probably the most loosely used word in exercise physiology, represents that complex of factors which accumulate in activity and which detract from the ability of the individual to continue the activity (11).

Riedman (17) states there are at least three aspects of fatigue: (1) the feeling of tiredness, bodily weariness, or disinclination to continue with the task because of bodily discomfort or a sense of bordeom--in any case, an unpleasant subjective experience; (2) reduced capacity for work, a falling off of efficiency as measured by work output which can be determined objectively; (3) temporary physiological changes in the organism, presumably caused by the accumulation of the products of work, tending to upset chemical equilibrium.

The effects upon performance of a state of fatigue are not just a decrement in performance itself, but may be much more complex. With the onset of fatigue, individuals are

likely to change the pattern of the task performance itself. The subject may use an increased amount of effort, use different and more extensive muscle systems than those which are adequate, or require excessively long rest periods after a given amount of work. Any or all of these factors are a distortion of performance under a state of fatigue (5).

Endurance is the capacity for prolonged work and is a measure of the ability to ward off fatigue. There are two types of endurance: muscular endurance and circulatory endurance. Muscular endurance is defined by Clark as "the ability to continue muscular exertions of sub-maximal magnitude" (2, p. 203). Circulatory endurance, as defined by Clark, is "moderate contractions of large muscle groups for relatively long periods of time, which require an adjustment of the circulatory-respiratory systems to the activity" (2, p. 203).

To aid in achieving a better understanding of the psychology and physiology involved, de Vries (4, p. 322) made an analysis of endurance as a factor in human performance:

A. Psychological Elements
    1. Motivation
    2. Willingness to take pain
B. Physiological Elements
    1. Local endurance: involvement of only one, or several, localized muscle groups

a) Strength of a particular muscle group

b) Energy stores: ATP and glycogen

c) Peripheral circulatory factor

2. General endurance: whole body activity

a) Strength of general musculature

b) Energy stores: ATP and glycogen

c) Systemic circulatory factor

1) Aerobic activity: limited by maximal O_2 consumption

(a) Respiratory function

(b) Cardiac output

(c) O_2-carrying-capacity of blood

(d) Vascularization of muscle tissues

2) Anaerobic activity: limited by ability to contract O_2 debt

(a) Alkaline reserve: blood buffers

(b) Willingness to take pain

d) Efficiency of heat regulatory mechanisms

e) Effectiveness of the nervous system in maintaining high levels of skill and coordination

3. Muscular efficiency: energy input required to bring about desired level of muscular performance.

There is frequently difficulty in separating the kinesthetic sensation and perception from that of touch and

vision, and this has partially contributed to the difficulty of measuring kinesthetic acuity. Measurements of kinesthesis have come through efforts of physical educators and can be traced through studies such as Phillips and Summers (15), Scott (20), Wiebie (25), and Young (26).

Phillips and Summers (15) contributed toward the clarification of the question of kinesthesis and motor performance. In their study one hundred and fifteen college women were classified as slow or fast learners on the basis of improvement shown during twenty-four class periods of bowling. Twelve positional measures of kinesthesis were tested. Results showed the following: there is a realtionship between motor learning and positional measures of kinesthesis; the kinesthetic sense is more important in early stages of learning a motor skill than in the later stages; and there are real differences between the preferred and non-preferred arms in kinesthetic perceptivity.

In her study of kinesthesis in relation to selected movements commonly used in gymnastics and sports activities, Young (26) encountered two problems: the problem of devising tests to measure kinesthesis and the problem of the relationship of kinesthesis to general ability. Scores of arm and leg positioning, of hitting targets, and reproducing standard pressures on a hand dynamometer were used in Young's study. Due to the limitations of available criteria for measuring kinesthesis, the study failed to achieve desired results.

Bass (1) undertook the tasks of establishing reliable balance tests and determining the different factors affecting balance. In order to establish reliable tests for dynamic and static balance, three hundred and fifty university women were tested, and to determine the factors which affect balance, one hundred and nineteen university women were tested. Several balance tests were proposed including the "Stepping Stone Test" for dynamic balance and the "Stick Test" for static balance. The findings, as they related to static balance, revealed that two types of tests were sufficient for measuring static balance. These tests required a person to stand straight with one foot crosswise on the stick or one foot lengthwise on the stick. Balance on both tests was performed with eyes open. The second problem of the Bass study was to determine the different factors affecting balance. For this purpose a battery of fourteen static balance tests was given. It was disclosed that different factors such as vision and kinesthesis, affect balance.

Scott (20), in an attempt to establish tests for measurement of kinesthesis, gave twenty-eight tests of kinesthesis and two of motor ability to one hundred college women. Then she administered fifteen of these tests plus one new one to seventy college women. There were four tests judged to measure some aspects of balance: (1) balance leap, (2) balance stick, (3) weight shifting, and (4) body sway. The results of these balance tests indicated that

balance is important in measuring kinesthesis and that tests of balance should be included in every kinesthetic test battery.

Fleishman and Rich (6), in a study of kinesthesis and spatial-visual abilities in perceptual-motor learning, validated the hypothesis that when an individual is learning a new perceptual motor task the eyes are most important in controlling the movement. Then as the individual practices, the kinesthetic cues are more prevalent. Subjects were undergraduate males from Yale University. A Two-Hundred Coordination apparatus was used for practice; then subjects were given a test of spatial orientation and of kinesthetic sensitivity. The conclusion was in keeping with hypothesis described.

Efforts to develop a test of kinesthesis have resulted in the conclusion that there are specific elements which require a battery of tests for adequate measurement. Although several of these elements have been identified by different researchers, no agreement exists regarding the best means for measuring each of them. Since kinesthesis is assumed to be dependent upon the proprioceptors and labyrinthine receptors, it is generally concluded that tests for kinesthesis should not make use of one's vision (13, p. 294).

Wiebie (25), in a study of tests of kinesthesis, administered twenty-one tests of kinesthesis to fifteen

college varsity men and fifteen college men who had never lettered in high school or college varsity sports. Conclusions were as follows: fifteen of the tests of kinesthesis have reliability coefficients which would recommend each of them as a useful testing instrument; that there is a kinesthetic difference in favor of athletes; and that the best combination of tests to measure kinesthesis in college men is the Balance, Lengthwise Test, Leg Raise Test, Vertical Space Test, and Separate Feet Test.

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CHAPTER II

PROCEDURES IN THE DEVELOPMENT OF THE STUDY

Procedures which were used for the development of the study are presented in this chapter.

Preliminary Procedures

As a preliminary procedure, extensive reading was done in the areas of fatigue and kinesthesis. Previous studies related to this study were reviewed and pertinent information was utilized.

Selection of Subjects

The subjects in the study were sixty-one men, volunteers, from required physical education classes at North Texas State University, fall semester, 1968. Each subject was informed of the necessary requirements involved in the study. The requirements consisted of the following in one day: completing two of the four tests for kinesthesis, working to the point of fatigue on the Harvard Step bench and then being re-tested. After an interval of two days, each subject was to complete the other two tests for kinesthesis, work to the point of fatigue and be retested.

The subjects participating in the testing program were uniformly dressed in the physical ecucation uniform required by the Department of Health, Physical Education and

Recreation for Men. Subjects volunteering from gymnastic classes were asked to bring a pair of tennis shoes rather than use the regular light-weight gymnastic slipper, due to the fact that the slipper did not give enough support and would let the foot over-lap the one-inch by one-inch by twelve-inch stick and touch the floor, while taking the balance, lengthwise test.

Selection of Tests

The selection of tests for this study was governed by the objectives of the study, review of the literature, and availability of facilities and equipment. The criteria used for selection of the tests were validity, reliability, objectivity, and ease of administration.

The Harvard Step Test was chosen as the method to be used to induce fatigue due to availability of facilities and apparatus and in view of similar studies (1, 4).

General Procedures in Test Administration

Prior to the testing, necessary facilities and equipment were made available and arranged in such a manner that they would facilitate the administration of the tests. The equipment included a twenty-inch bench, an electronic metronome, a stop watch, a blindfold, a yardstick, a balance stick, one inch by one inch by twelve inches long, a life-size stick figure drawing with leg raised to a twenty-degree angle, a mat, and a goniometer.

Each subject began the testing program with the separate feet test. The subject was instructed to first put the blindfold on and stand with heels together, and then separate his feet so that his heels would be twelve inches apart. Chalk marks were made inside the subject's heels and he was then instructed to step forward and repeat the same procedure for a total of three trials. Chalk marks were measured and recorded to the nearest one-fourth inch.

The vertical linear space test was the second test administered. The subject was seated in a chair, facing the wall, with a yardstick taped to the wall. The subject was instructed to visualize the sixteen-inch mark; he was then blindfolded and told to point to the sixteen-inch mark for a total of three trials. Scores were recorded to the nearest one-fourth inch.

The subject was next given instructions concerning the Harvard Step Test, which consisted of stepping up and down on a twenty-inch bench thirty times per minute. The electronic metronome was started and the subject was instructed to begin and to continue stepping to the cadence of one hundred and twenty times per minute until he became exhausted or until the instructor stopped him. The subjects were stopped fifteen seconds after they began to fall behind the cadence.

The subjects, after stepping ceased on the step bench, were instructed to move immediately to the separate feet test area. The subject was blindfolded and instructed to repeat the separate feet test for a total of three trials and to move immediately to the vertical linear space test area. The subject was seated and directed to visualize the sixteen-inch mark and then was blindfolded and told to repeat the vertical linear space test for a total of three trials. Scores were again recorded to the nearest one-fourth inch.

The subject reported two days later to take the remaining two tests of the four-test battery. The balance, lengthwise test was the third test administered. Each subject was blindfolded and instructed to step upon the one-inch by one-inch by twelve-inch stick with his dominant foot, and to lift the other foot off the floor. The subject was told that he would be timed from the moment his nondominant foot was lifted off the floor until he touched the floor with any part of his body. After one practice trial, he was timed for a total of three trials and scores were recorded to the nearest one-half second.

The leg raise test was then administered. The subject was instructed to lie on his nondominant side; he was shown a stick figure drawing with its leg raised at a twenty-degree angle. The subject was then blindfolded and instructed to duplicate the twenty-degree angle seen in the stick figure

drawing. Three trials were allowed and each was measured with a goniometer and recorded to the nearest degree.

The Harvard Step Test was again utilized to induce fatigue. Upon reaching the point of fatigue, the subject was directed to the balance, lengthwise test area and was blindfolded and instructed to repeat the balance, lengthwise test for a total of three trials. Scores were again recorded to the nearest one-half second. The subject was directed immediately to the leg raise test area and told to repeat the leg raise test for a total of three trials; scores were recorded to the nearest degree.

Treatment of Data

Data were recorded for the sixty-one subjects who completed all the tests. The scores were recorded in terms of raw scores. Data were analyzed statistically through the use of the means, standard deviations, and *t* tests. Through the use of the *t* test, a comparison was made between the pre-test scores and the post-test scores of each of the four tests for kinesthesis in order to determine whether or not a significant difference occurred between them. Differences in scores were significant if they exceeded the .05 level of confidence.

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CHAPTER III

PRESENTATION OF DATA

This chapter presents an analysis and interpretation of the findings of the study. Tests were administered to sixty-one subjects registered for physical education at North Texas State University during the fall semester, 1968. These tests were chosen to explore the effects of fatigue on kinesthetic perception.

The data obtained from the pre-test and post-test of each of the four kinesthetic tests were organized so that they could be analyzed statistically. The data are presented in the Appendix.

Means and standard deviations were computed for the pre-test and the post-test of each of the four kinesthetic tests. To determine the significance of the difference between the means the Fisher *t*-test, as described by McNemar (2, p. 101-102), was employed as the statistical technique.

Table I presents the means of the pre-test and the post-test, the differences between the means, and the *t* values for the separate feet test, the vertical space test, the balance, lengthwise test, and the leg raise test.

TABLE I

SIGNIFICANCE OF DIFFERENCES BETWEEN MEANS FOR THE PRE-TEST AND POST-TEST OF THE FOUR KINESTHETIC TESTS

Kinesthetic Tests	Pre-Test		Post-Test		Difference between means	*t
	Mean	S.D.	Mean	S.D.		
Separate Feet Test (N=61)	7.13	3.53	4.74	3.46	2.39	3.66
Vertical Space Test (N=61)	10.08	3.75	11.38	3.39	-1.30	-2.61
Balance, Lengthwise Test (N=61)	11.37	4.20	9.87	4.44	1.50	2.66
Leg Raise Test (N=61)	10.70	5.95	9.85	5.54	.85	.98

*A t of 2.00 is required to denote significance at the .05 level.

The data utilized to compute the means of the pre-test and the post-test of each of the four tests for kinesthesis are the total of three trials of each of the following:

Separate Feet Test--deviation from the preferred score of twelve inches; each trial was recorded to the nearest one-fourth inch.

Vertical Space Test--deviation from the preferred score of sixteen inches; each trial was recorded to the nearest one-fourth inch.

Balance, Lengthwise Test--each trial was recorded to the nearest one-half second.

Leg Raise Test--deviation from the preferred angle of twenty degrees; each trial was recorded to the nearest degree.

Summary of the Findings

The results revealed the following findings relative to performance on the four kinesthetic tests by college men.

1. In a comparison of the means of the pre-test and post-test of the separate feet test, in relationship to the preferred score for accuracy, subjects scored more accurately on the pre-test.

2. In a comparison of the means of the pre-test and post-test of the vertical space test, in relationship to the preferred score for accuracy there was a reversal in the effects: subjects scored more accurately on the post-test.

3. In a comparison of the means of the pre-test and post-test of the balance, lengthwise test, in relationship to the total time, subjects balanced longer on the pre-test.

4. In a comparion of the means of the pre-test and post-test of the leg raise test, in relationship to preferred angle for accuracy, the differences were not significant.

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CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a summary, conclusions, and recommendations based upon the results of this study.

Summary

The study was to investigate the effects of induced fatigue on performance of the separate feet test, which consisted of separating feet so that heels were twelve inches apart; the vertical space test, which consisted of pointing to a designated point on a yardstick; the balance, lengthwise test, which consisted of balancing on a one-inch by one-inch by twelve-inch long stick; and the leg raise test, which consisted of raising the dominant leg to a designated angle.

The four kinesthetic tests were administered to sixty-one men enrolled in physical education classes at North Texas State University. For a more varied sampling, volunteers were taken from five different activity classes. The different activities included weight training, gymnastics, basketball, wrestling, and weight lifting.

The Harvard Step Test was utilized to induce fatigue and then the subjects were immediately retested on the

kinesthetic tests. Data for determing any significant differences were provided by scores of the pre-test and post-test of the four kinesthetic tests.

The Fisher *t* was the statistical technique selected to determine the significance of the differences between the means. The .05 level of significance was selected for all statistical treatment.

Conclusions

The results would seem to warrant the following conclusions concerning the effects of fatigue on the four kinesthetic tests.

1. The results of the separate feet test suggest the possibility that a person's sense of distance through which a part of the body moves is impaired with the onset of fatigue. This could affect adequate performance in a number of motor acts such as balance beam routines and floor exercise routines in gymnastics and proper stance in basketball, and weight-lifting.

2. The results of the vertical space test were the reverse of the other test results, but this could possibly be due to the manner in which fatigue was induced. The arms were not utilized in the Harvard Step Test, possibly were not fatigued, and the exercise was just a "warm-up" period.

3. The results of the balance, lengthwise test suggest that a person's sense of balance is impaired with the onset

of fatigue. This could affect adequate performance in a number of motor acts, such as all gymnastic skills, wrestling, diving, skating, skiing, etc.

4. The results of the leg raise test were not significant enough to warrant any conclusions.

Recommendations

As a result of this study, the following recommendations for future studies are made.

1. It would seem desirable to conduct a similar study utilizing college women.

2. The use of junior high and senior high school boys and girls as subjects to determine if fatigue affects their kinesthetic perception would also be desirable.

3. The use of more numerous kinesthetic tests is suggested.

4. It would also seem desirable to conduct a study using a more extensive fatiguing period.

5. It would seem desirable to conduct a study of the effects of fatigue on arm positioning, but the method of inducing fatigue should utilize the arms.

APPENDIX A

TABLE II

RAW SCORES

SEPARATE FEET TEST

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
1	.50	0	.50	1.0	0	.50	2.00	2.50
2	1.25	4.00	1.50	6.75	1.00	1.50	.75	3.25
3	1.75	.75	2.00	4.50	.50	.75	1.25	2.50
4	3.75	.75	0	4.50	.75	.75	1.50	3.00
5	1.50	2.00	1.00	4.50	0	.25	.50	.75
6	1.00	.75	.75	2.50	1.75	1.75	.50	4.00
7	5.50	5.50	4.00	15.00	3.50	1.50	.75	5.75
8	6.50	5.25	4.00	15.75	3.00	1.50	.50	5.00
9	2.50	4.00	5.00	11.50	2.00	2.50	2.00	6.50
10	1.00	3.50	.75	5.25	4.00	6.00	5.00	15.00
11	5.00	5.00	5.00	15.00	3.00	1.25	3.50	7.75
12	4.50	2.75	2.00	9.25	1.00	2.25	0	3.25
13	2.50	1.75	2.75	7.00	2.50	2.50	2.50	7.50
14	4.00	3.00	3.25	10.25	1.50	1.50	2.00	5.00
15	5.00	4.25	5.50	14.75	1.50	.25	.25	2.00
16	.75	1.00	.50	2.25	3.50	4.75	3.75	12.00
17	1.00	2.00	1.00	4.00	1.25	3.00	.50	3.75
18	3.75	3.25	2.50	9.50	2.00	1.00	.25	3.25
19	3.75	1.75	3.00	8.50	0	.75	0	.75
20	2.00	.50	.50	3.00	3.75	4.00	5.00	12.75
21	2.50	3.50	.75	6.75	1.00	.25	0	1.25
22	1.75	1.25	2.75	5.75	1.25	.50	.25	2.00
23	4.50	2.50	2.00	9.00	.50	.50	1.50	2.50
24	4.50	4.00	3.25	11.75	1.25	.50	1.50	3.75
25	2.75	2.75	1.00	6.50	.50	.50	.25	1.25
26	4.50	3.50	2.75	10.75	1.50	1.00	.50	3.00
27	2.25	2.75	2.75	7.75	3.00	2.00	1.50	4.50
28	5.00	4.25	3.25	12.50	.50	2.00	.25	2.75
29	1.50	1.25	1.50	4.25	2.00	2.00	2.00	6.00

TABLE II

(CONTINUED)

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
30	2.50	2.50	3.00	8.00	4.00	4.00	6.25	14.25
31	4.75	3.75	1.00	9.50	0	3.00	1.00	4.00
32	2.75	2.25	3.00	8.00	1.50	1.75	.25	3.50
33	1.50	2.00	0	3.50	.50	0	2.00	2.50
34	4.25	1.50	3.00	8.75	1.75	.50	7.50	9.75
35	4.75	2.75	2.75	10.25	1.50	.25	.25	2.00
36	2.50	1.00	2.25	5.75	1.00	1.00	1.00	3.00
37	2.50	3.50	1.75	7.75	2.50	.50	3.00	6.00
38	1.00	.75	0	1.75	.25	1.00	.50	1.75
39	3.50	1.50	1.50	6.50	0	1.25	2.50	3.75
40	1.00	2.00	2.00	5.00	.50	2.75	2.50	5.75
41	0	1.75	2.50	4.25	0	1.00	1.00	2.00
42	2.75	2.25	2.00	7.00	3.25	1.75	2.00	7.00
43	3.75	2.50	.75	7.00	2.75	1.00	.25	4.00
44	0	2.00	3.00	5.00	.50	.75	1.50	2.75
45	4.00	2.50	2.00	8.50	.50	4.00	3.00	7.50
46	4.25	3.75	4.25	12.25	0	.50	.25	.75
47	4.50	2.75	0	7.25	2.00	0	1.25	2.25
48	1.00	.75	.50	2.25	6.75	1.50	2.00	10.25
49	.75	2.00	4.00	6.75	4.00	2.75	6.00	12.75
50	3.25	3.50	1.00	7.75	3.75	3.75	3.75	11.25
51	4.00	3.50	3.25	10.75	.75	.50	5.00	6.25
52	3.50	0	1.00	4.50	.50	3.50	6.00	10.00
53	3.50	2.75	1.50	7.75	1.50	2.00	0	3.50
54	2.00	1.00	1.00	4.00	.50	1.75	1.50	3.75
55	2.50	0	.50	3.00	.50	.25	.25	1.00
56	3.00	1.25	0	4.25	1.00	2.00	1.00	4.00
57	1.50	.50	1.75	3.75	0	.50	1.50	2.00
58	0	.50	1.00	1.50	1.00	.50	1.50	3.00
59	4.00	2.25	.50	6.75	0	.50	.50	1.00
60	2.00	1.75	.50	4.25	3.00	1.50	.50	5.00
61	2.75	4.25	4.00	11.00	1.25	2.25	3.00	6.50

APPENDIX B

TABLE III

RAW SCORES

VERTICAL LINEAR SPACE

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
1	3.25	4.25	4.00	11.50	5.00	4.25	5.50	14.75
2	2.00	1.50	2.00	5.50	2.00	1.50	1.50	5.00
3	4.00	4.00	3.50	11.50	3.00	2.00	2.75	7.75
4	7.50	6.75	7.25	21.50	7.00	6.50	5.25	18.75
5	5.50	6.75	4.75	17.00	4.25	5.75	6.00	16.00
6	2.25	3.75	2.50	8.50	3.00	2.75	3.75	9.50
7	2.00	1.50	1.00	4.50	2.50	3.50	3.50	9.50
8	3.00	3.00	4.00	10.00	4.50	3.00	2.00	9.50
9	4.00	4.00	4.50	12.50	3.50	4.75	5.00	13.25
10	4.50	3.50	3.50	11.50	5.00	5.50	5.00	15.50
11	5.25	4.75	4.25	14.25	4.50	5.25	5.50	15.25
12	3.50	5.25	3.00	11.75	3.50	5.25	4.75	13.50
13	1.75	4.00	4.00	9.75	5.50	4.50	4.00	14.00
14	2.50	2.50	2.50	7.50	3.00	3.50	3.00	9.50
15	.50	1.50	2.25	4.25	2.50	2.50	2.00	7.00
16	5.00	2.50	2.50	10.00	3.50	2.50	2.50	8.50
17	2.50	3.25	4.25	10.00	4.00	4.25	4.50	12.75
18	3.25	2.00	3.25	8.50	4.00	4.25	3.50	11.75
19	3.25	3.25	2.00	8.50	2.50	3.00	3.00	8.50
20	5.00	4.25	4.25	13.50	4.75	4.00	5.00	13.75
21	1.00	1.00	2.00	4.00	1.75	1.25	1.75	4.75
22	1.50	3.50	2.00	7.00	4.00	4.00	4.75	12.75
23	2.50	.50	1.00	4.00	4.50	3.50	4.00	12.00
24	3.25	3.25	4.00	10.50	3.50	4.00	4.25	11.75
25	3.75	5.50	5.50	14.75	4.25	5.25	7.25	16.75
26	3.00	1.50	1.25	5.75	5.00	4.25	4.00	13.25
27	3.00	3.50	3.75	10.25	4.50	4.25	4.25	13.00
28	4.25	4.00	4.00	12.25	4.25	4.00	4.00	12.25
29	3.00	3.75	4.50	11.25	4.00	3.75	5.50	13.25

TABLE III

(CONTINUED)

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
30	3.00	3.75	4.50	11.25	3.50	3.00	4.50	11.00
31	3.00	4.00	4.75	11.75	2.75	4.25	4.00	11.00
32	4.25	2.50	1.50	8.25	3.75	3.25	4.00	11.00
33	2.75	2.00	2.00	6.75	5.00	6.00	4.25	15.25
34	3.50	3.25	3.25	10.00	4.50	4.25	2.50	11.25
35	6.00	5.00	4.75	15.75	4.25	4.00	4.00	12.25
36	2.25	2.25	.50	5.00	2.75	3.00	4.00	9.75
37	3.00	2.50	2.50	8.00	3.25	3.25	2.50	9.00
38	3.00	2.50	3.50	9.00	2.00	3.00	2.00	7.00
39	3.75	4.00	3.00	10.75	3.75	4.50	4.00	12.25
40	5.25	6.25	4.50	16.00	4.75	3.00	4.50	12.25
41	4.75	4.25	4.00	13.00	5.00	4.25	4.50	13.75
42	2.50	2.50	1.50	6.50	2.75	3.00	4.00	9.75
43	5.50	3.75	6.00	15.25	5.00	5.50	5.50	16.00
44	5.00	4.25	4.00	13.25	2.00	1.75	1.25	5.00
45	4.50	4.50	5.25	14.25	2.75	1.50	2.00	6.25
46	4.25	4.50	4.50	13.25	5.00	5.00	4.50	14.50
47	1.50	1.25	3.50	6.25	5.25	5.00	5.75	16.00
48	4.00	4.25	2.75	11.00	2.50	2.50	2.75	7.75
49	1.75	3.75	2.50	8.00	5.50	5.50	5.00	16.00
50	2.25	1.25	1.75	5.25	4.50	3.50	4.00	12.00
51	3.25	4.00	4.00	11.25	5.00	6.00	5.25	16.25
52	3.50	3.00	1.00	7.50	3.50	2.75	3.00	9.25
53	3.50	3.50	3.50	10.50	3.00	2.50	2.75	8.25
54	2.00	3.25	3.50	8.75	5.25	6.00	3.50	14.75
55	3.00	3.25	3.25	9.50	3.50	2.50	1.75	7.75
56	2.50	2.00	2.00	6.50	3.00	2.50	3.00	8.50
57	1.00	2.50	3.00	6.50	2.75	3.00	3.50	9.25
58	4.25	5.50	5.75	15.50	4.50	4.50	4.50	13.50
59	3.25	3.50	3.00	9.75	4.00	3.50	3.00	10.50
60	4.00	5.75	6.50	16.25	5.00	4.25	6.00	15.25
61	1.25	1.00	.25	2.50	2.75	2.00	2.75	7.50

APPENDIX C

TABLE IV

RAW SCORES

BALANCE, LENGTHWISE

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
1	2.00	4.00	5.50	11.50	4.00	3.00	3.00	10.50
2	4.00	16.50	3.00	23.50	5.50	6.00	6.50	17.50
3	2.00	3.00	5.50	10.50	2.50	2.50	1.00	6.00
4	3.50	5.00	3.50	12.00	3.00	2.50	1.00	6.50
5	4.50	4.50	6.00	15.00	6.00	3.00	3.00	12.00
6	10.50	7.50	4.50	23.00	4.50	10.00	5.50	20.00
7	4.50	3.00	2.00	9.50	4.50	2.50	3.00	10.00
8	3.00	3.50	3.50	10.00	2.00	3.50	2.50	8.00
9	5.00	2.50	4.00	11.50	3.00	2.50	1.50	7.00
10	2.50	3.50	3.50	9.50	3.50	2.00	3.50	9.00
11	5.00	3.50	13.50	22.00	10.00	2.00	2.50	14.50
12	2.50	6.50	5.00	14.00	8.00	3.00	4.50	15.50
13	7.00	2.50	2.50	12.00	5.00	3.50	3.00	11.50
14	4.50	1.50	4.00	10.00	3.00	4.50	4.50	12.00
15	5.00	1.50	2.00	8.50	1.50	2.00	1.00	4.50
16	3.00	3.00	4.50	10.50	1.50	4.00	2.50	8.00
17	3.50	1.50	3.50	8.50	4.50	4.50	2.00	11.00
18	3.00	2.00	2.00	7.00	1.50	4.00	3.50	9.00
19	1.50	2.50	1.50	5.50	2.50	2.00	2.00	6.50
20	1.00	3.00	2.50	6.50	4.00	2.50	2.50	9.00
21	2.50	3.00	2.00	7.50	1.50	1.50	2.50	5.50
22	5.00	6.50	2.50	14.00	7.50	4.50	7.50	19.50
23	3.50	2.50	4.50	10.50	1.00	4.50	9.00	14.50
24	2.50	7.00	7.00	12.50	2.50	2.50	3.00	8.00
25	2.50	1.50	3.50	7.50	1.00	1.50	1.50	4.00
26	4.00	4.00	2.00	10.00	8.50	7.00	10.50	26.00
27	5.50	4.00	4.50	14.00	2.00	4.00	3.00	9.00
28	3.00	3.00	3.00	9.00	2.00	2.50	1.50	6.50
29	5.00	6.00	5.50	16.50	3.50	4.50	4.50	12.50

TABLE IV

(CONTINUED)

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
30	3.50	4.50	3.00	11.00	5.00	4.00	2.50	11.50
31	3.50	4.50	4.00	12.00	4.50	3.50	3.00	11.00
32	3.00	3.50	3.50	10.00	4.00	6.00	10.50	20.50
33	2.50	4.50	4.00	11.00	1.50	1.50	1.50	4.50
34	4.00	6.00	5.50	15.50	2.50	1.50	2.00	6.00
35	4.00	2.00	2.50	8.50	3.50	1.50	2.00	7.00
36	1.50	3.00	2.00	6.50	1.50	2.00	1.00	4.50
37	6.50	2.50	4.50	13.50	1.50	1.50	1.50	4.50
38	2.00	4.00	7.50	13.50	2.50	2.00	2.00	6.50
39	2.50	2.00	3.50	8.00	1.50	2.00	3.00	6.50
40	2.50	2.00	2.00	6.50	2.00	2.00	2.00	6.00
41	3.50	3.00	2.00	8.50	2.00	2.00	3.50	7.50
42	3.00	2.50	2.00	7.50	3.00	2.00	2.00	7.00
43	4.50	4.00	1.50	10.00	4.50	2.50	4.50	11.50
44	4.50	2.50	3.00	10.00	2.50	3.50	3.00	9.00
45	6.00	7.50	2.00	15.50	4.00	4.00	3.50	11.50
46	4.00	7.00	2.50	13.50	3.00	7.00	5.00	15.00
47	3.50	7.50	9.50	20.50	3.50	3.50	3.50	10.50
48	3.00	5.50	1.50	10.00	1.50	2.00	3.50	7.00
49	2.00	2.00	1.00	5.50	2.00	2.00	2.00	6.00
50	2.00	2.50	3.50	7.00	3.00	2.50	2.00	7.50
51	5.00	5.50	5.50	16.00	3.50	4.50	4.50	11.50
52	4.00	1.50	4.00	9.00	2.00	2.50	2.50	7.00
53	3.50	6.50	3.50	13.50	4.50	4.00	5.00	13.00
54	2.00	4.00	4.50	10.50	4.50	2.00	3.00	9.50
55	5.50	2.50	4.50	12.50	6.00	6.00	4.50	16.50
56	9.00	2.00	10.50	20.50	3.00	3.50	5.00	11.50
57	6.00	6.50	2.50	15.00	3.00	3.50	3.50	10.00
58	4.50	1.50	3.00	9.00	1.50	3.50	1.50	6.50
59	3.00	2.00	3.00	8.00	2.00	2.50	2.50	7.00
60	1.50	2.00	2.00	5.50	2.00	3.00	4.00	9.00
61	2.00	2.50	3.50	8.00	2.00	2.00	2.00	6.00

APPENDIX D

TABLE V

RAW SCORES

ON SIDE LEG RAISED 20°

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
1	4	8	8	20	2	2	4	8
2	0	2	3	5	3	5	6	14
3	1	3	2	6	4	4	4	12
4	5	2	1	8	2	4	2	8
5	1	0	4	5	0	3	5	8
6	3	2	3	8	2	0	1	3
7	2	1	1	4	1	1	2	4
8	3	2	0	5	0	2	3	5
9	1	3	5	9	2	0	3	5
10	4	5	5	14	1	4	4	9
11	3	3	3	9	6	5	4	15
12	8	7	8	23	8	5	6	19
13	2	2	1	5	7	7	3	17
14	5	6	5	16	8	10	11	29
15	4	5	5	14	0	2	2	4
16	2	3	2	7	1	2	0	3
17	4	2	4	10	5	3	4	12
18	4	2	6	12	1	1	1	3
19	3	2	2	7	3	3	2	8
20	10	8	9	27	5	5	7	17
21	2	2	2	6	1	5	1	7
22	4	4	3	11	3	4	5	12
23	3	3	3	9	1	2	2	5
24	2	6	7	15	4	4	4	12
25	4	5	3	12	4	5	5	14
26	3	4	4	11	2	2	4	8
27	0	3	1	4	2	2	2	6
28	4	6	5	15	2	1	2	5
29	2	2	2	6	2	4	3	9

TABLE V

(CONTINUED)

	Pre-Test				Post-Test			
Subj.	1	2	3	Total	1	2	3	Total
30	6	6	6	18	1	2	5	8
31	0	0	0	0	8	6	4	18
32	5	7	7	19	3	3	1	7
33	3	2	2	7	3	4	6	13
34	2	5	4	11	5	4	3	12
35	5	5	6	16	2	2	4	8
36	2	0	2	4	1	3	3	7
37	2	1	1	4	1	0	1	2
38	5	7	5	17	7	6	6	19
39	0	5	4	9	0	2	1	3
40	8	10	6	24	8	3	2	13
41	4	2	4	10	4	3	2	9
42	4	3	3	10	6	6	6	18
43	5	3	5	13	5	3	2	10
44	6	5	2	13	5	4	4	13
45	7	3	3	13	2	1	3	6
46	3	2	0	5	4	4	1	9
47	2	2	5	9	1	0	0	1
48	2	2	2	6	4	2	3	9
49	4	3	1	8	3	1	4	8
50	7	5	3	15	4	4	4	12
51	3	1	1	5	1	0	1	2
52	3	5	7	15	1	3	3	7
53	6	4	7	17	8	9	7	24
54	10	9	9	28	3	6	5	14
55	3	3	3	9	3	1	0	4
56	4	3	2	9	3	3	1	7
57	0	1	1	2	6	4	6	16
58	1	0	2	3	2	2	1	5
59	3	2	3	8	2	4	4	10
60	4	3	2	9	4	4	5	13
61	4	5	4	13	3	5	5	13

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