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# A Study of the Changes Caused by Modern Dance Movement on Flexiblity and Balance of College Freshman Football Players

Daniel J. Neppel

This thesis submitted by Daniel J. Neppel in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

W. C. Koenig
Chairman

John L. Quaday

Christopher J. Hamre
Dean of the Graduate School

# A STUDY OF THE CHANGES CAUSED BY MODERN DANCE MOVEMENT ON FLEXIBILITY AND BALANCE OF COLLEGE FRESHMAN FOOTBALL PLAYERS

by

Daniel J. Neppel

B. S. in Education, University of North Dakota 1964

A Thesis

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of the

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ABSTRACT

This abstract submitted by Daniel J. Neppel in partial fulfillment of the requirements for the Degree of Master of Science in the University of North Dakota is hereby approved by the Committee under whom the work has been done.

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Daniel J. Neppel, Master of Science

The thesis here abstracted was written under the direction of Mr. Walter C. Koenig and approved by Dr. John L. Quaday and Dr. Allen W. Sturges as members of the examining committee, of which Mr. Koenig was Chairman.

The purpose of this study was to determine the changes elicited by modern dance techniques on the flexibility and body balance of college freshman football players.

Two groups were requested to participate in the study. An experimental group of fifteen subjects, which experienced a modern dance program twice weekly, and a control group of thirteen subjects, that did not participate in modern dance, were utilized in this study.

The two groups were given a pretest for flexibility with the Leighton Flexometer and a pretest for body balance with the Stork Stand Test for Balance. The same items were also administered at the conclusion of the modern dance program.

Two statistical comparisons were made: (1) A within group comparison between the pretest and retest means of each group, and (2) a comparison between the means on the retests of each group in the area tested. The null hypothesis was assumed in analyzing the significance of the difference between

means at the .05 level.

The results of comparison showed a significant decrease by the control group in two of the five areas tested. The control group also evidenced a decrease in a third area tested, but this decrease was not statistically significant.

It was concluded, on the basis of the results of the within groups comparison, that modern dance increased flexibility and body balance in college freshman football players.

# CHAPTER I

## INTRODUCTION

The rise of spectator sports, as a recreational pursuit, has become a cultural phenomenon in our time. It is a rare person who has not attended a game or watched an athletic contest through modern television. It has been these spectators, or often termed "rabid spectators", who have pressured coaches and athletic administrators into the "win or else" era of athletics.

Since coaches in intercollegiate athletics have been the primary targets of criticism for failure to win, they have been constantly searching for ways to improve the ability of each performer on their team. Football coaches, in particular, have attempted many methods in an effort to teach a boy how to perform the necessary skills more efficiently.

### A. Purpose of the Study

The investigator made this study attempting to evaluate:

1. The effect modern dance would have upon trunk and hip flexion and extension.

2. The effect of modern dance upon leg abduction.

3. The effect modern dance would have upon body balance or equilibrium.

## B. Delimitations of the Study

The study was limited to 28 freshman football players at the University of North Dakota, Grand Forks, North Dakota.

The ages of the subjects ranged from 18 to 22 years of age.

The study was conducted for a complete semester with the first meeting on February 3, 1965 and the last meeting held on May 19, 1965. The experimental group attended the exercise periods on Tuesdays and Thursdays of each week beginning at 2:10 p.m. and ending at 2:50 p.m.; a total of 40 minutes of exercise.

## C. Definitions of Terms

Flexibility: The potential and existing ranges of movement of a body segment with respect to another segment. Example: backward and forward movement of the trunk.

Modern dance movement: Movements or exercises demanding control of body segments to produce a position of that body segment for a desired display of the body line.

Trunk and hip flexion: Bending of the upper trunk of the body and the hips from a standing position to a forward, bent over position.

Trunk and hip extension: Bending from a standing position with the knees locked, to an extended or bent back position.

Leg abduction: Moving the leg laterally away from the middle or median line of the body.

Body balance: The ability to maintain the center of gravity or equilibrium in an area relative to the movement desired so as not to lose that stability and fall. In football, this could involve maintaining a wide base or stance when charging straight ahead in a football lineman's charge.

Flexometer: An instrument used in establishing the degrees of flexibility.

Motor skills: Physical movements or skills requiring a voluntary response from the nervous system to perform until a reflex has been established through continual performance or repeated practice.

Range of motion: The distance in degrees that a body segment moves in respect to the joint through or about which it moves.

Freshman college football players: High school graduates or transfer students from other schools participating in their freshman year in intercollegiate football.

## D. Need for the Study

Motor skill performance has entered the game of intercollegiate football through theories and practices established by coaches of the game. These men have felt it a necessity to improve this ability in their players to better the win records they have attempted to establish. As a result of their efforts, some have written books concerning their theories and methods. Mr. Gomer Jones,[1] a very successful line coach at the University of Oklahoma, has

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[1] Gomer Jones, Offensive and Defensive Line Play (New Jersey: Prentice-Hall, Inc., 1964), p.11.

written the following concerning the physical ability of college football players:

> The development of body control, agility and the ability to react with accuracy is as important as the development of offensive and defensive fundamentals. Without these required skills, players will not be able to execute the offensive and defensive fundamentals.

Mr. Ben Martin,[2] head football coach at the United States Air Force Academy, has written a text concerning his methods and theories of teaching football skills. His remarks have been noted by many coaches and teachers in the field of sport and intercollegiate football:

> On every play in a football game, the players are required to put their bodies through a number of complex movements.
>
> . . . . . .
>
> What a player inacts [sic] requires coordination, for coordination is the combined action of a number of muscles to produce complex movements. A good football prospect must be coordinated, not clumsy. He must be able to react to what he sees and to the pressures he feels inflicted by the opponent upon his body.

Body balance or equilibrium is desired by coaches as a necessity to perform well as a college football player. It is well known that the principle of a wide base or stance is an aid in the maintenance of equilibrium. Thus, if a boy can maintain a relatively stable state of equilibrium, while being tackled or blocked, he may perform well as a running back or defensive linebacker. This quality may be inherent in the athlete, and if it is not, the coach should make efforts to increase this physical attribute in his performer. Doubtless, the coach will try to improve the equilibrium through daily drills. However, it is more desirable that these boys develop body balance before coming to camp

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[2] Ben Martin, Ben Martin's Flexible T Offense (New Jersey: Prentice-Hall, Inc., 1961), p.13.

in the fall.

Bunn[3] has stressed the importance of equilibrium or body balance in sports:

> Equilibrium is probably the most significant of all physical principles, in mechanics, that are involved in sports technique.
> . . . . . .
> In sports parlance, it is called balance, position and stance. Depending upon the results desired, various aspects of equilibrium are maintained.

Still another important aspect, which has been of concern to intercollegiate football coaches, is the physical condition of their athletes. Noted persons in the field of physical education and athletics have made statements concerning the necessary physical qualities or requirements for fitness. Rathbone[4] has written:

> A person who is fit is usually relatively strong. His strength is in his muscles. He is agile. Agility depends upon nervous system control. He is flexible. Flexibility is in the joints.

Cureton[5] has expressed his theories concerning flexibility and physical fitness:

> Flexibility of men of college age display a type of "suppleness" which is a measure of the full-range of mobility of the joints reflecting the structural capacity, the normality of joints, the strength of the musculature and type and condition.

Physical condition in athletics and daily living has been a necessary requirement for utmost performance and enjoyment by all individuals. It has

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[3] John W. Bunn, Scientific Principles of Coaching (New Jersey: Prentice-Hall, Inc., 1964), p.4.

[4] Josephine L. Rathbone, Corrective Physical Education (Philadelphia: W. B. Saunders Company, 1949), p. 92.

[5] Thomas K. Cureton, "Flexibility as an Aspect of Physical Fitness", Research Quarterly (Vol. XII, May, 1941), p. 381.

been stated that body flexibility plays a distinctive role in aiding the individual to reach this level in physical fitness.

Intercollegiate coaches have known that flexibility effects the motor performance of individuals. This theory has been established through studies and experiments on flexibility and its relation to motor ability performance.

Tyrance[6] has concluded that motor ability performance depends upon many factors, among which is joint mobility or flexibility.

Flexibility and body balance, or equilibrium, are primary requisites for college football players. This necessity has motivated coaches in all fields of athletics to give their athletes some type of activity to improve body control and flexibility. Modern dance programs have been widely introduced by coaches to improve the motor efficiency of football players on the intercollegiate level. But needless to say, fans have felt this to be humorous and used as a means for publicity. Many coaches who have used this technique have been interested in the positive effects of modern dance movement upon increased flexibility and body balance. They have also been curious as to whether or not flexibility can be increased through specific exercises and if strength is lost in doing so.

Taylor[7] has completed a study which gives some insight to possible answers to these questions. From his investigation, Taylor concluded that flexibility can be improved through prescribed exercises without a subsequent

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[6] Herman J. Tyrance, "Relationships of Extreme Body Types to Ranges of Flexibility", Research Quarterly (Vol. XXIX, No. 3, October, 1958), p. 17.

[7] L. Taylor, "Studies in Flexibility" (Unpublished Master's Thesis, Springfield College, 1938), p. 74.

decrease in strength.

Leighton,[8] a leading researcher in flexibility, has concluded from his studies, that the range of motion of a normal joint can be changed or increased through activity.

From the foregoing statements, it would seem there is a definite need for evaluation of modern dance technique and its effect on flexibility and body balance in college freshman football players. This review of the need for the study revealed the following significant points:

1. Flexibility is a factor in attainment of good physical condition.
2. Flexibility is a requirement for efficient performance of motor skills.
3. Flexibility can be increased through specialized activity.
4. Strength is not lost in attempting to increase flexibility.
5. Body balance or equilibrium is desired by coaches in intercollegiate football to perform the necessary football fundamental skills more efficiently.
6. Certain coaches have attempted to improve the flexibility of their football players through various modern dance programs to produce winning teams.
7. An evaluation of a modern dance program is needed to determine the effect it has upon changing the flexibility of college freshman football players.

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[8] Jack R. Leighton, "On The Significance of Flexibility for Physical Educators", Journal of Health, Physical Education and Recreation (November, 1960), p. 27.

## CHAPTER II

## REVIEW OF RELATED LITERATURE

Studies and experiments attempting to evaluate flexibility changes as a result of modern dance movement are limited. The research conducted by this investigator has not revealed any studies in the area of modern dance in relation to flexibility in college freshman football players.

The review of the related literature in this study was done with reference to studies completed in flexibility of athletes as compared to regular college students. The investigator feels these studies have sufficient bearing on this study to be mentioned here.

Leighton[1] conducted a study in which he tested 100 basketball players, 100 baseball players, 50 swimmers and 44 shot putters and discus throwers, to determine the flexibility characteristics of these athletes in their respective skill groups. He found the swimmers attained the highest degree of flexibility in 25 or the 30 test items administered.

Leighton also found that baseball players had about the same degree of flexibility as did the swimmers. Basketball players showed superior performance in 14 of the 30 movements administered; while the trackmen were inferior to the other three skill groups in the 30 test items of flexibility. Leighton

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[1] Jack R. Leighton, "Flexibility Characteristics of Four Specialized Skill Groups of College Athletes", Archives of Physical Medicine and Rehabilitation (Vol. XXXIII, No. 1, January, 1957), p. 24.

concluded that a definite need exists for studies to determine if there is a possibility of improvement of skills through direct individual improvement in flexibility.

Haliski[2] concluded that football players were less flexible than physical education service class students in body articulations. Haliski studied 100 University of Oregon football players with the use of the Leighton Flexometer and compared the results with 56 members of a body building class at Oregon.

Haliski administered the flexibility movements devised by Leighton as the criterion for testing his subjects. His results showed that football players at the University of Oregon were significantly more flexible than the service program subjects in side hip extension only.

In a comparison of linemen and backfield performers, Haliski found the backfield men to be more flexible in 12 of the 21 measures compared.

A more significant study was one conducted by Peter O. Sigerseth and Haliski[3] at the University of Oregon. They used 100 football players and 100 regular college students in their study.

The two investigators administered the flexibility test movements devised by Leighton and measured the degrees of range of motion with the Leighton Flexometer. The football subjects were given ample time to train

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[2] Chester C. Haliski, "A Study of Flexibility in Football Players" (Unpublished Master's Thesis, University of Oregon, 1950).

[3] Peter O. Sigerseth and Chester C. Haliski, "The Flexibility of Football Players," Research Quarterly (Vol. XXI, No. 4, December, 1950), p. 394.

in the sport of football before being measured. Each subject was tested twice in succession on each movement and the results recorded.

Haliski and Sigerseth statistically computed the reliability of the methods of testing the flexibility of the subjects. A comparison was made between the results of the first and second trials on each movement. They recorded a coefficient of correlation of .953 for leg abduction of the left leg and a coefficient of .945 for abduction of the right leg. A reliability coefficient of .971 was found for trunk and hip flexion and extension. It may be of significance to mention here that these movements and the same instrument were used by this investigator to test his subjects for flexibility in these anatomical areas.

Sigerseth and Haliski compared 21 joint areas of the body of football players with those of regular college students. Their results showed that, in the groups studied, regular college students were significantly more flexible than football players in a greater number of body joints.

There is evidence from the review of related literature supporting the theory of a lack of flexibility in college football players and college athletes in their respective skill activities. Football players are more flexible in side hip extension only. College students were found to be more flexible in 13 other joint areas of the body. Additional evidence showed that college students were again more flexible than college footballers in a greater number of body joints.

Recently instruments have been devised which accurately determine the flexibility of joints in various anatomical regions of the body. Evidence has shown these measuring instruments to be reliable in measuring trunk and hip flexion and extension and leg abduction.

# CHAPTER III

# METHODOLOGY

## A. Selection and Equation of the Two Groups Used in the Study

Two groups of fifteen freshman football players each, one experimental, the other control, were selected from a total of thirty-five freshman football players at the University of North Dakota. They were asked to volunteer for participation in this study, and to enroll in a service program course which met twice weekly for sixty minutes at each meeting.

The control group was reduced to fourteen members, as a result of a schedule conflict upon registration. This same group was again reduced, due to the death of a subject, before the testing was completed. This limited the control group to a total of thirteen subjects.

Since the method of selection of the subjects was not by random, these groups had to be equated to bear evidence that neither group was physically more flexible or had, as an inherent quality, better body balance. Therefore, these groups were equated for flexibility on the basis of trunk and hip flexion by comparing the initial test scores in trunk and hip flexion of both the experimental and control groups. It was found that the difference between these two groups for purposes of equating them was of no significance, as shown by the standard error of the difference between two means for

uncorrelated groups.[1]

Both groups were equated for body balance by comparing the initial test scores of both groups for the Stork Stand. This test was adapted from the Iowa Revision of the Brace Test[2] and is used in this study to attempt to determine body balance in these subjects. It was found that the standard error of the difference between the means for uncorrelated groups showed no evidence of significant difference between the experimental group and control group.

On the basis of these tests, it has been assumed these two groups are significantly equal in relation to body flexibility in areas tested, and to body balance as equated by the use of the Stork Stand test for balance.

Raw scores, mathematical procedure, and the formulae used in equating the groups are recorded in Appendix A.

### B. Description of the Instrument and Test Items Used in the Study

The instrument utilized in measuring the degrees of flexibility, in trunk and hip flexion and extension and leg abduction, was a type of goniometer devised by Jack R. Leighton[3], known as the Leighton Flexometer (see Figure 1). The instrument is equipped with a flat, rotating circular dial, marked off in

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[1] Allen L. Edwards, Statistical Methods For The Behavioral Sciences (New York: Rinehart and Company, Inc., 1954), p. 252.

[2] Charles Harold McCloy and Norma Dorothy Young, Tests and Measurements in Health and Physical Education (New York: Appleton - Century Crofts, Inc., Third Edition, 1954), p. 88.

[3] Jack R. Leighton, "A Simple Objective and Reliable Measure of Flexibility", Research Quarterly, (Vol. XIII, No. 2, May, 1942), pp. 205 - 216.

degrees of a circle, and a movable pointer. Both the dial and the pointer are weighted and coincide with each other when the instrument is placed in an operating position. A strap is attached to bind the instrument to the moving part being measured. A locking device is provided for the dial and another for the pointer. The dial is locked at one extreme position, full extension of the hips, then a reading is taken. The next movement is made and the dial is locked at the extreme position, full flexion of the trunk and hips. A reading is taken at this position and recorded.

Figure 1

As a means of evaluating general body flexibility, the investigator selected the same movement (see Figures 2 and 3) as that devised by Leighton.[4] This movement was designed to measure trunk and hip flexion. Clarke[5] stated

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[4] Ibid., p. 212.

[5] H. Harrison Clarke, Application of Measurement to Health and Physical Education (New Jersey: Prentice-Hall, Inc., 1961), p. 175.

that trunk and hip flexibility have been an indication of general body flexibility.

The procedure that was followed during the measurement of trunk and hip flexion and extension was performed by the subject in two movements. The instrument was strapped around the chest of the subject directly below the armpit on either side of the subject. He was then instructed to stand at attention, feet flat on the floor, while keeping the hips stable. The dial and pointer were set at zero and the subject told to bend backward to the maximum position. At this point a reading was taken and recorded.

The measurement of trunk and hip flexion was conducted in the same manner. This time the subject was instructed to bend forward, keeping the knees straight, to the maximum position. Again, at this point, a reading was taken to the nearest degree. Each subject was given the opportunity to perform each movement once while the reading was taken. A second trial was not administered.

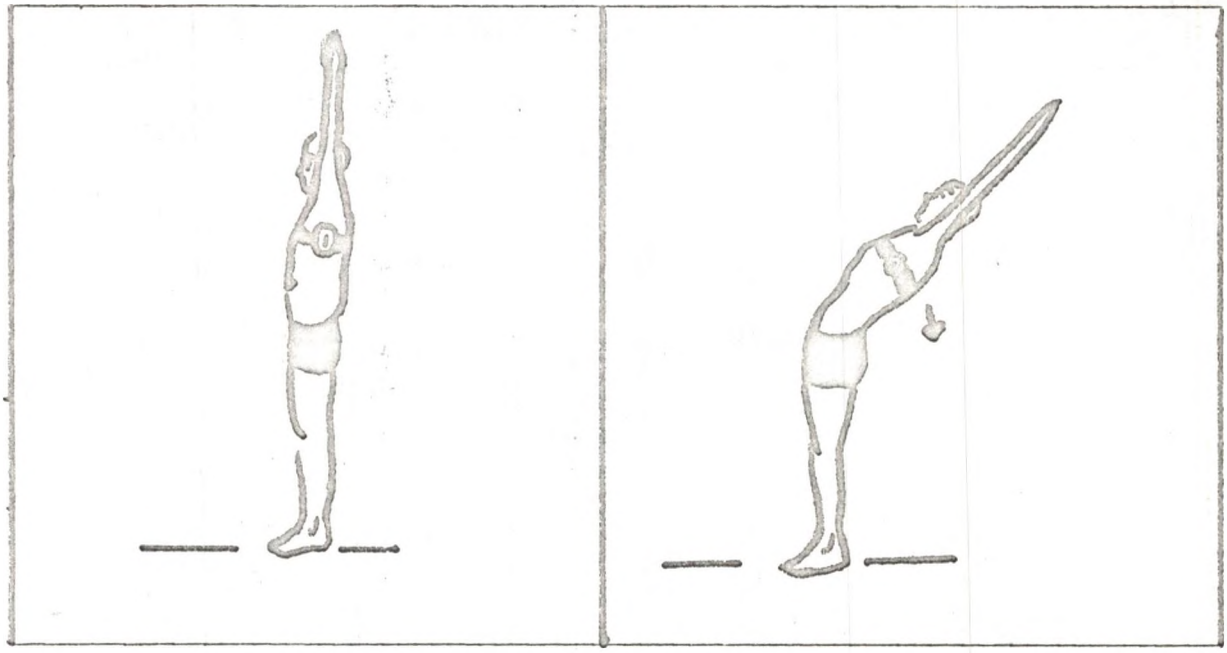

Figure 2 - Trunk and Hip Extension. Left - starting position; right - finishing position.

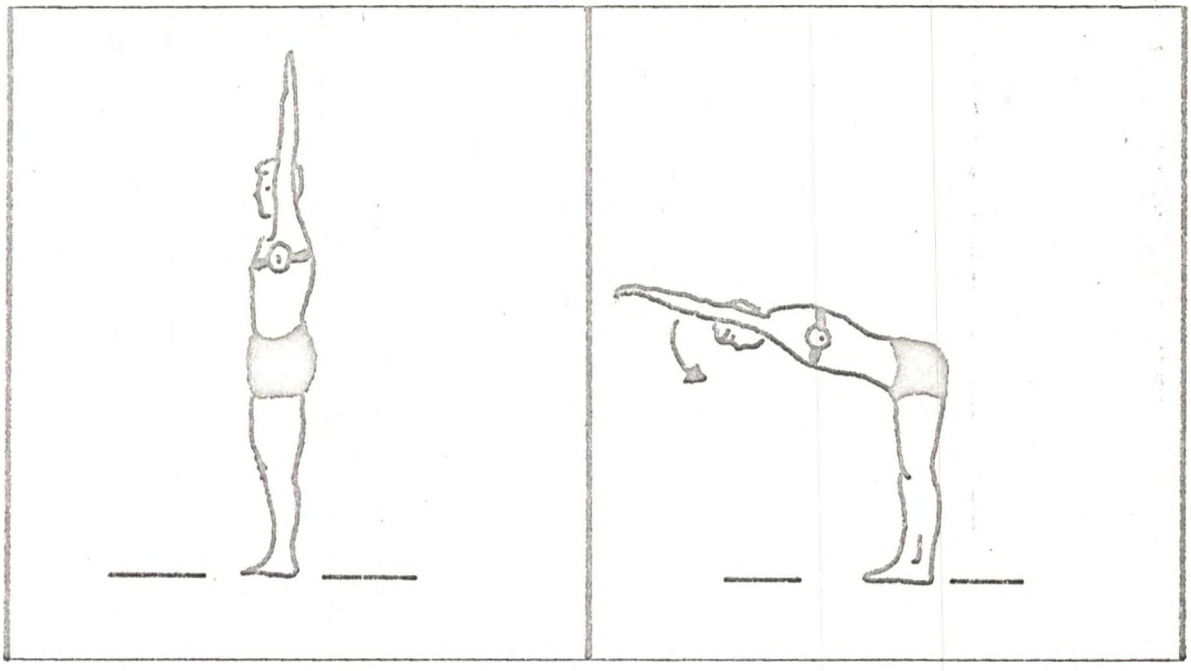

Figure 3 - Trunk and Hip Flexion. Left - starting position; right - finishing position.

The second measure adapted from Leighton's test of flexibility movements was movement VII or Leg Abduction (see Figure 4).

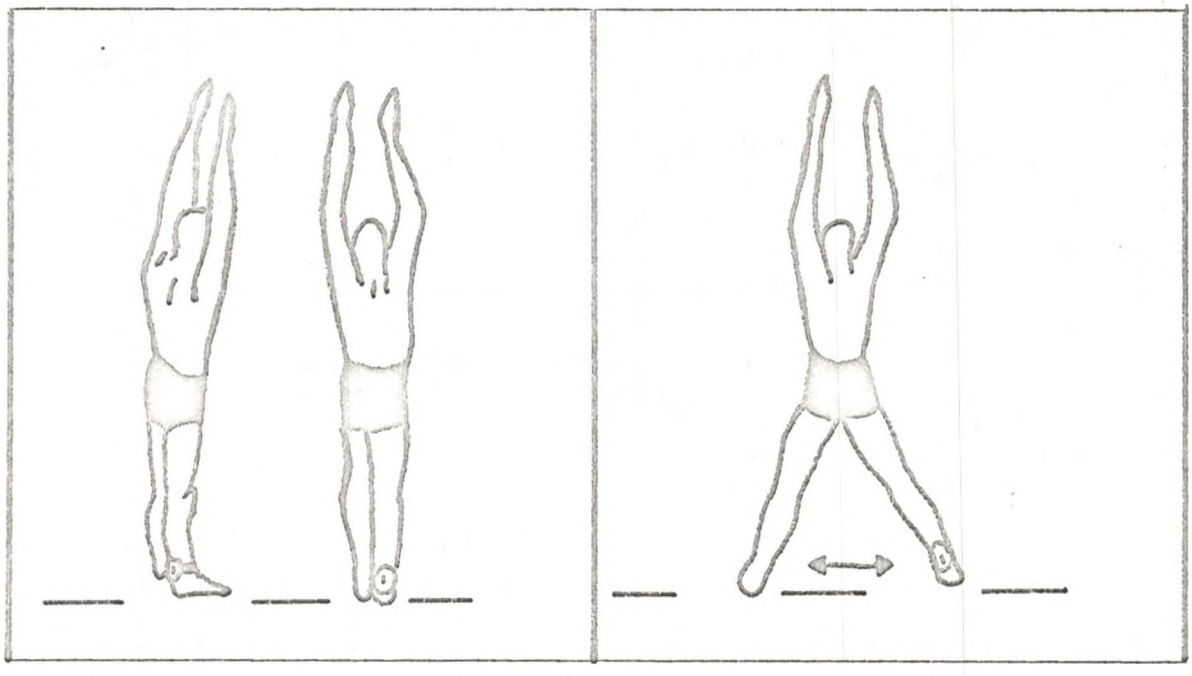

Figure 4 - Leg Abduction. Left - starting position; right - finishing position. The same procedure for either leg.

The instrument was strapped around the ankle with the flexometer on the back of the ankle. The subject was instructed to stand at attention (the dial and pointer set as close as possible to zero), and then to slide both feet out sidewards to the maximum position. At this position, the dial was locked and the reading was taken to the nearest degree and recorded. The same procedure was followed in the measurement of the degree of leg abduction in the opposite leg.

The stork stand was a third measure used by this investigator to evaluate body balance. This is test number five from the Iowa Revision of the Brace Test (see Figure 5).

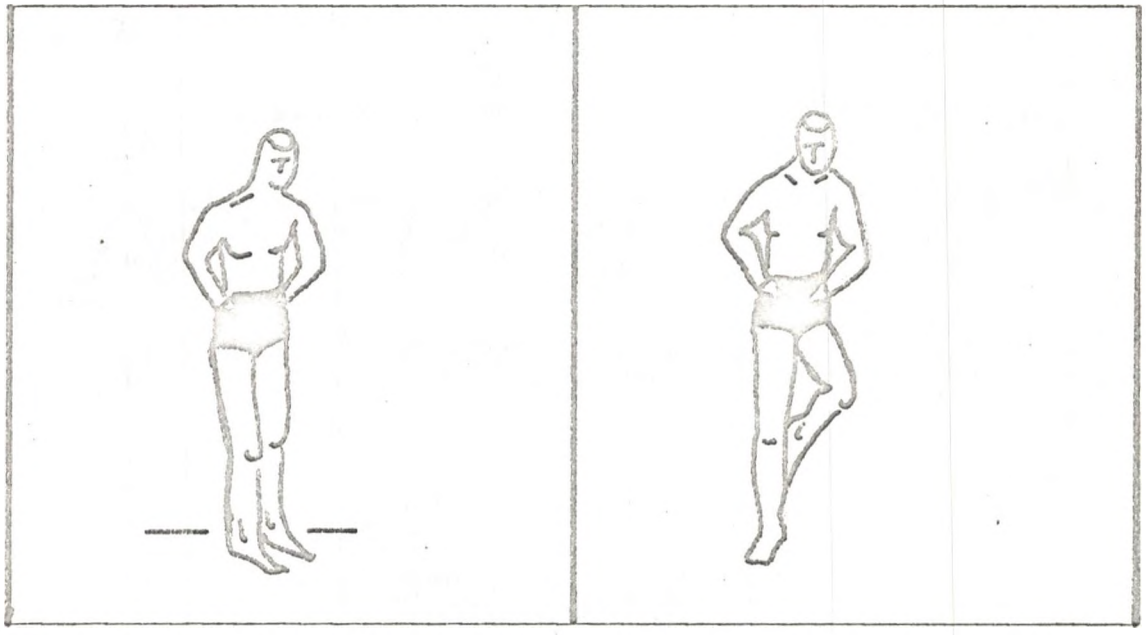

Figure 5 - Stork Stand Test for Balance. Left - starting position; right - holding and finishing position.

The subject was instructed to place his hands on his hips, place the insole of the left foot against the medial side of the knee of the right leg, with toes of the left foot pointing to the floor. He was allowed a moment to steady

himself, and then instructed to close his eyes. The subject was given one point for every second on a stop watch, up to and including ten seconds, that he was able to hold this position without losing balance, shifting the right foot on the floor, or opening his eyes. If the subject was unable to meet the above criteria for the maximum time of ten seconds, he was permitted another trial. The best score of both trials was then recorded.

Two other items selected from the Iowa Revision of the Brace Test to evaluate body balance, were deleted from the study upon completion of the analysis of data. The degree of difficulty of these test items was not sufficient to produce a large enough range in scores to have shown comparable results. None of the 28 subjects tested made scores below the maximum of ten on each of the two stunt items used in the initial testing phase or retest phase.

### C. Illustration, Description and Administration of the Treatment Exercises

The modern dance movement exercises used by the investigator in this study were of two types: (1) Exercises done without support, or floor exercises, and (2) movements done with support. Therefore, the following illustrations and descriptions will be divided into two separate sections according to type.

It is appropriate at this point to describe the dress worn by the experimental group subjects during the exercise period. The purposes for the dress were two: (1) To clearly distinguish the body line, and (2) to permit

freedom of movement during performance. A black, calf length tight, with a black tight tee-shirt was required for performance of the modern dance movements. The tights were footless, which permitted the experimental group and the writer to perform in bare feet. This factor gave a surer grip on the floor.

### D. Movements Without Support[6]

The sequence of these movements was continually followed when the exercises were used for warm-up purposes, as well as to improve flexibility and body balance. The program was introduced with floor exercises of the non-support type. Gradually the more difficult movements with support were added.

The instructor always spoke in a smooth, relaxing tone to encourage relaxation and stress deliberate movements. Talking or laughing was not permitted during performance. This seemed to encourage concentration on movement and relaxation during the exercise activity. The instructor counted rhythmically to insure uniform movement by the group.

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[6] Provided by Mrs. Mi Mi Marr, Dance Instructor, Women's Physical Education Department, University of North Dakota, Grand Forks, February, 1965.

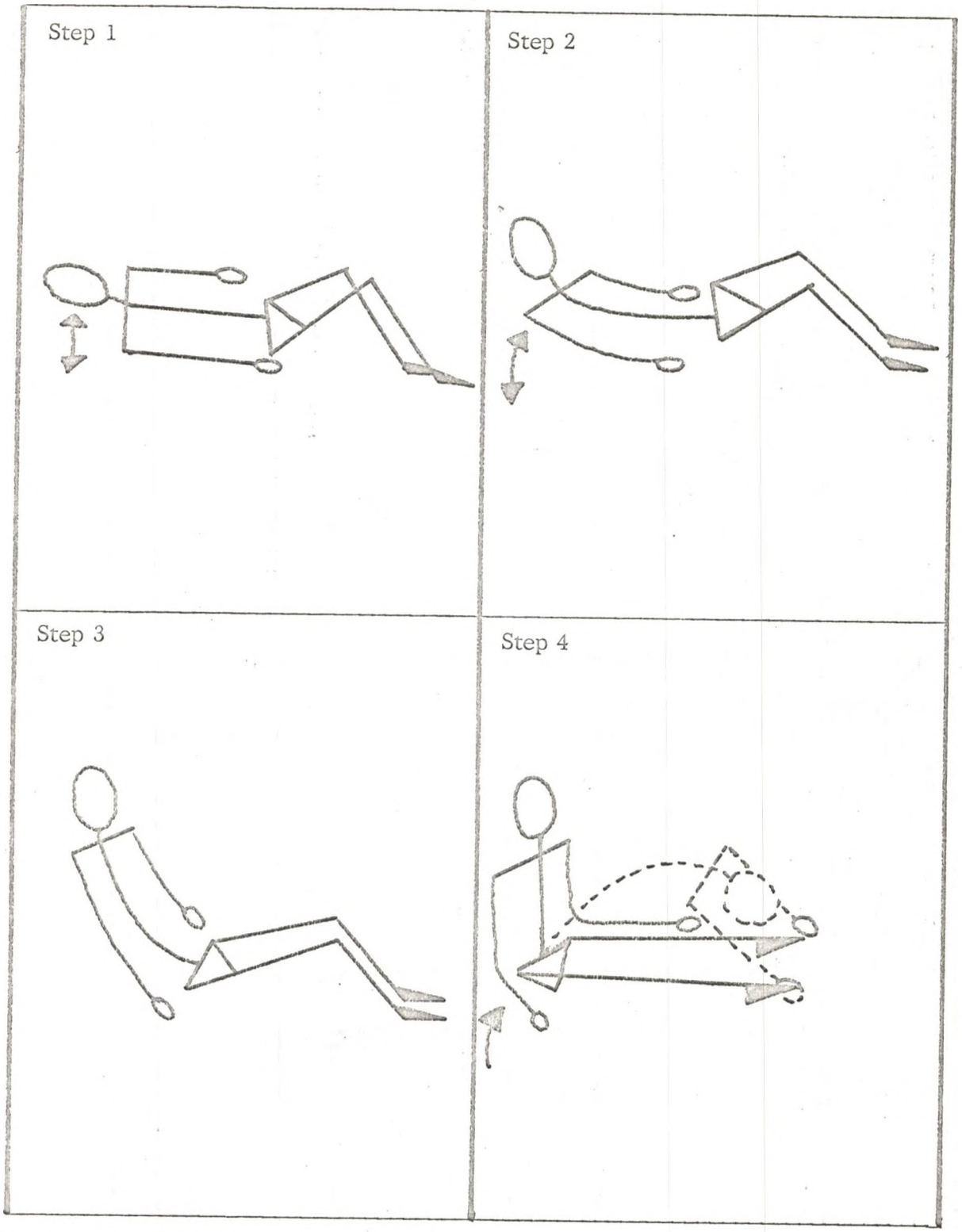



Figure 1 - Curl to Sit up and Touch

Movement I - Curl to Sit up and Touch

Start: Back lying position, arms at side, knees bent, feet on floor.

Step 1: Lift head, lower slowly to starting position.

Step 2: Lift head and shoulder, lower slowly.

Step 3: Lift head, shoulder and thorax, lower slowly to floor.

Step 4: Lift head, shoulders, thorax, trunk, come to sit position. Slide legs to extended position, depress knees and extend feet. Relax. Touch toes with hands, lower slowly. Repeat. Begin with step 1 (see Figure 1).

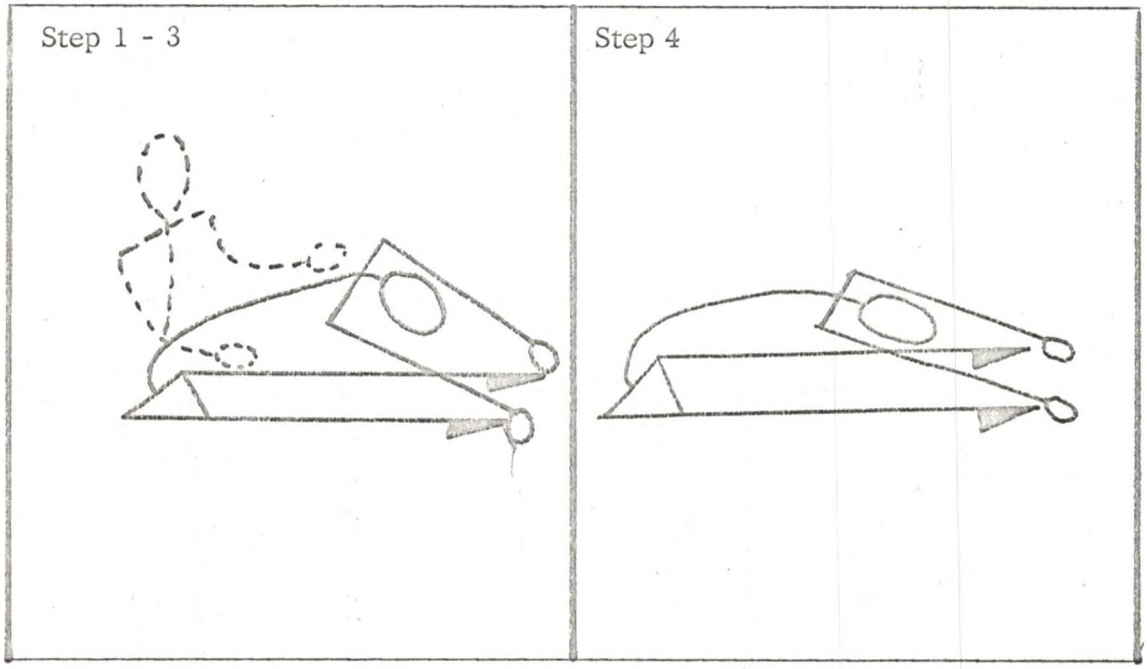



Figure 2 - Bounce from Sit position and hold.

Movement II - Bounce from Sit and Hold

Start: Sit up position, legs and feet extended, toes pointed, knees depressed.

Steps 1 - 3: Bounce, touch toes with fingers, then back to sit. Repeat four times.

Step 4: Bounce as in steps 1 - 3. On fifth bounce, grasp ankles, keep knees depressed, touch head to knees (see Figure 2).

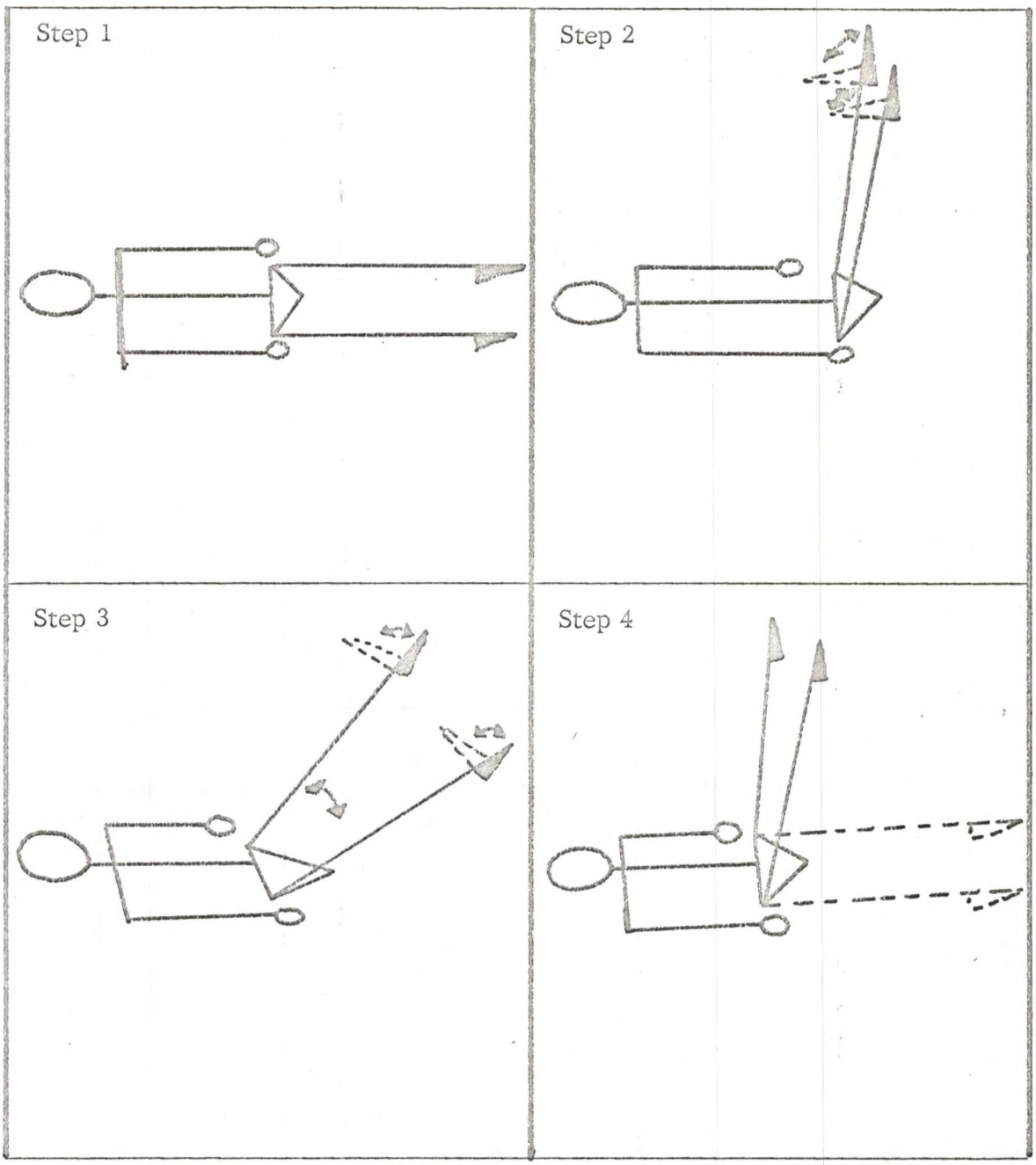



Figure 3 - Leg Lift and Foot Flex

Movement III - Leg Lift and Foot Flex

Start: Back lying position, legs extended, knees depressed, feet extended.

Step 1: Keep knees depressed, raise legs slowly to vertical position until perpendicular to hips.

Step 2: On count, flex both feet, then extend both feet.

Step 3: Separate legs, keep knees depressed, again flex and extend feet.

Step 4: Bring legs back together, extend feet, lower slowly to starting position. Keep knees depressed (see Figure 3).

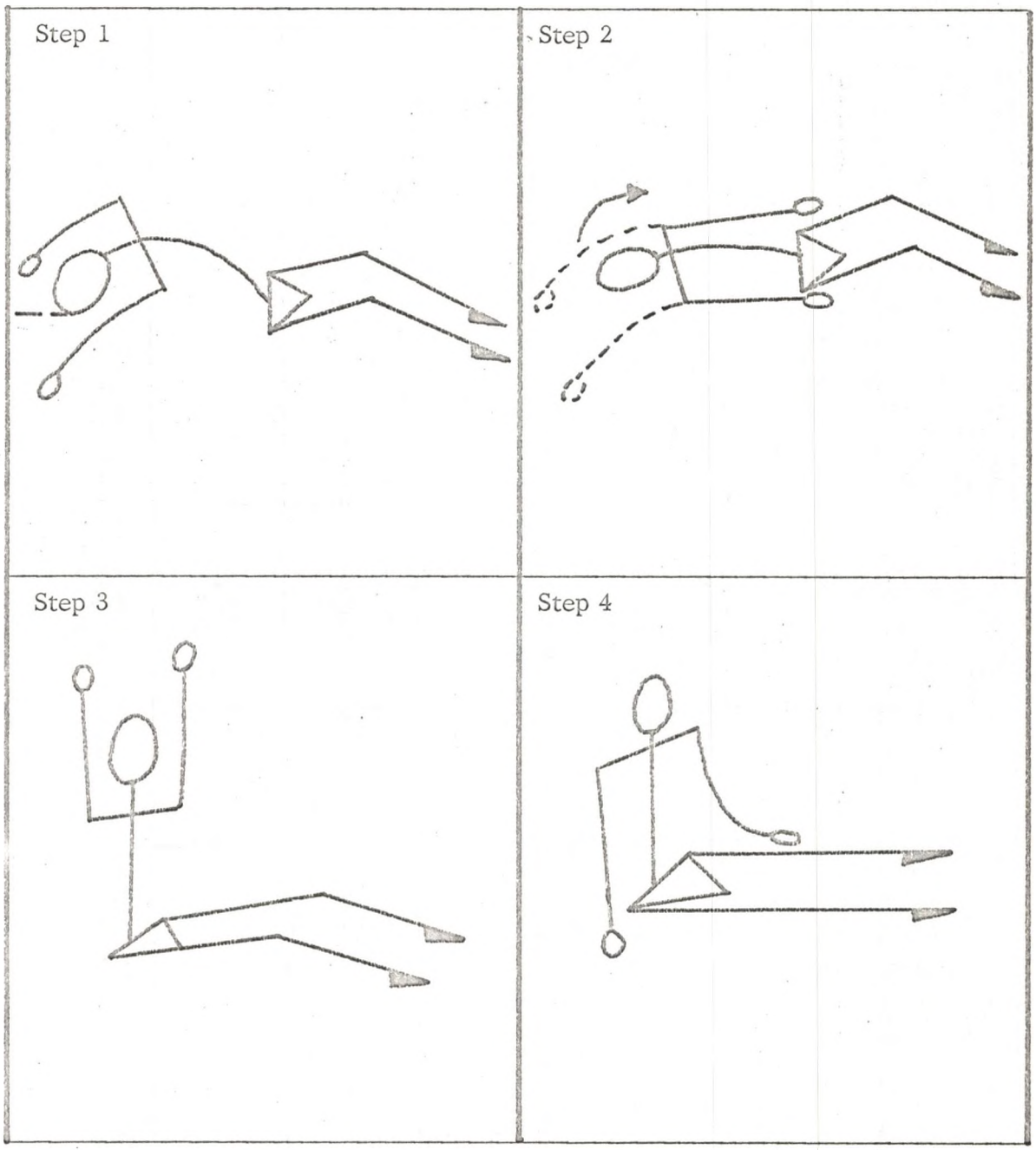



Figure 4 - Back Arch to Upswing and Sit.

Movement IV - Back Arch to Upswing and Sit

Start: Back lying position, knees bent, feet flat on floor.

Step 1: Arch back, extend arms above shoulders, come to rest on head, look back along floor to point on opposite wall.

Step 2: On signal, swing arms down along floor, and bring head up and toward feet.

Step 3: Follow through with arms, reach to ceiling, end in sit up position with legs extended.

Step 4: Exhale, let arms drop slowly to floor, relax and repeat steps 1 - 3 (see Figure 4).

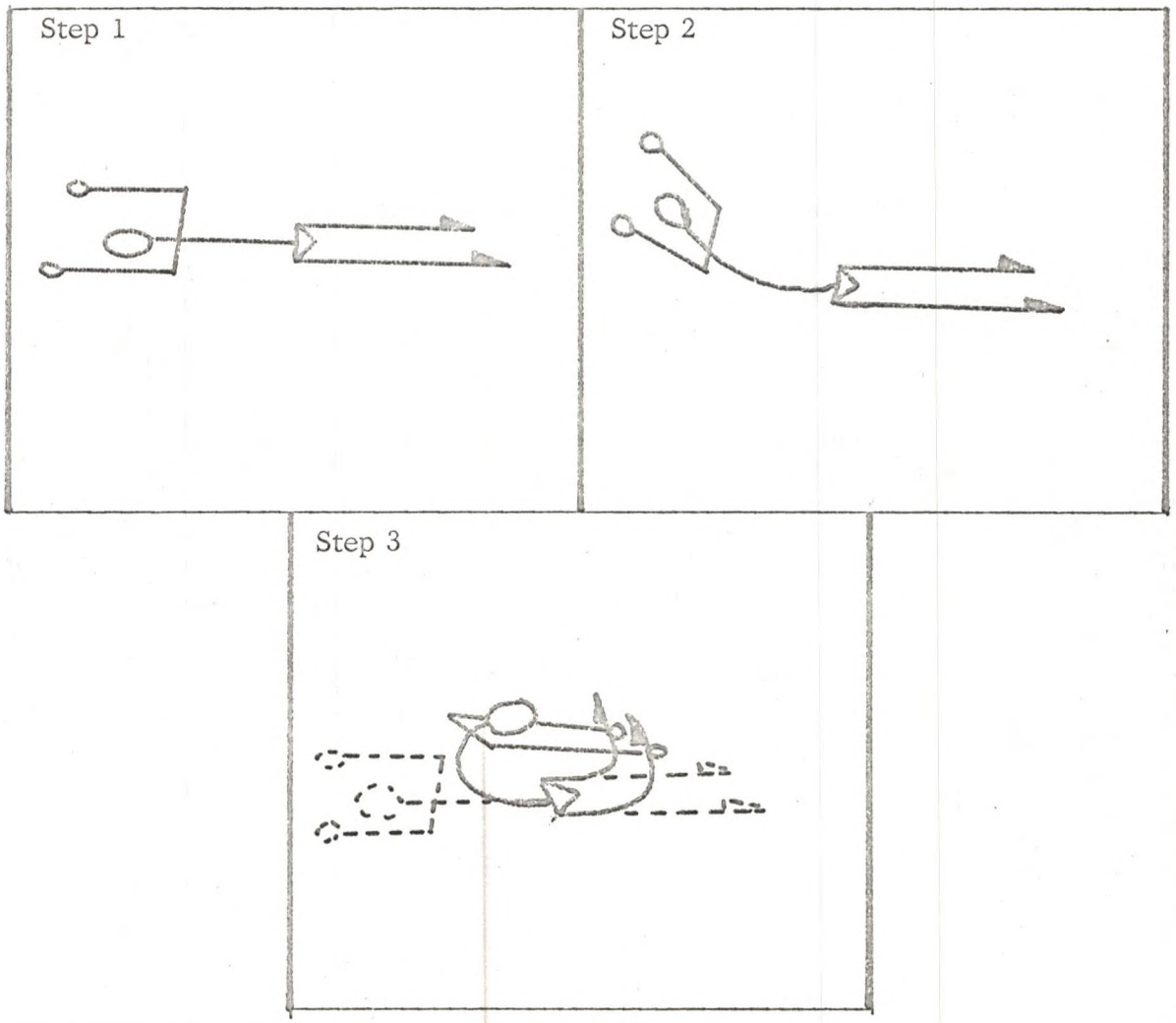



Figure 5 - Front Lying Position, Grasp Ankles.

Movement V - Front Lying Position, Grasp Ankles

Start: Lie prone, hands at sides, legs extended.

Step 1: Arch back, bring head up. Look along floor to point on opposite wall.

Step 2: Bring legs up, fully extend to rocker position.

Step 3: Grasp ankles with hands, hold, maintain arched position. Return to starting position and relax (see Figure 5).

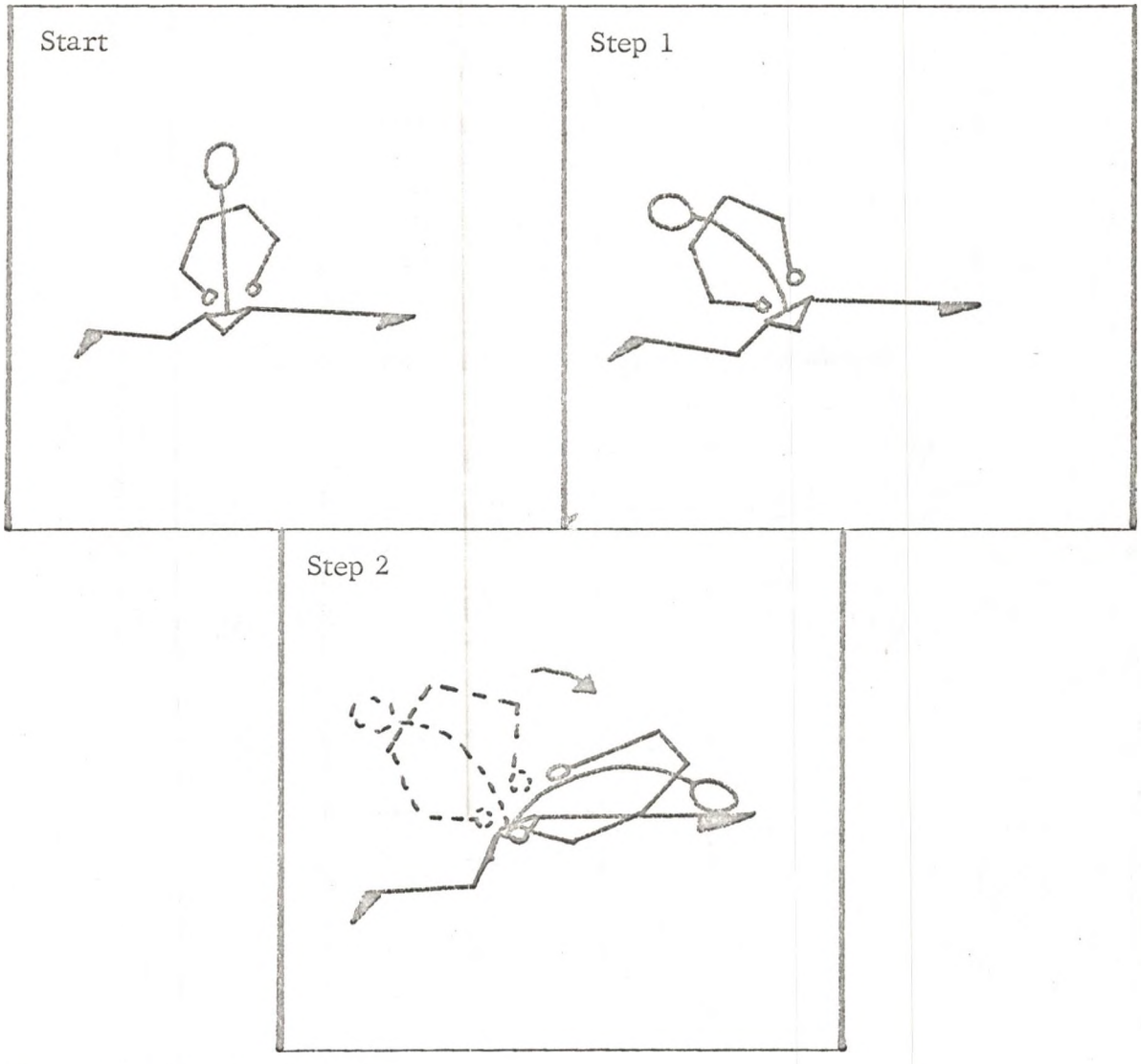



Figure 6 - Hurdler Stretch

Movement VI - Hurdler Stretch

Start: In sitting position, extend left leg while hooking opposite leg behind hip.

Step 1: Keep hands on hips, lean back as far as possible.

Step 2: Come forward through sitting position, touch forehead to extended leg, repeat on opposite leg (see Figure 6).

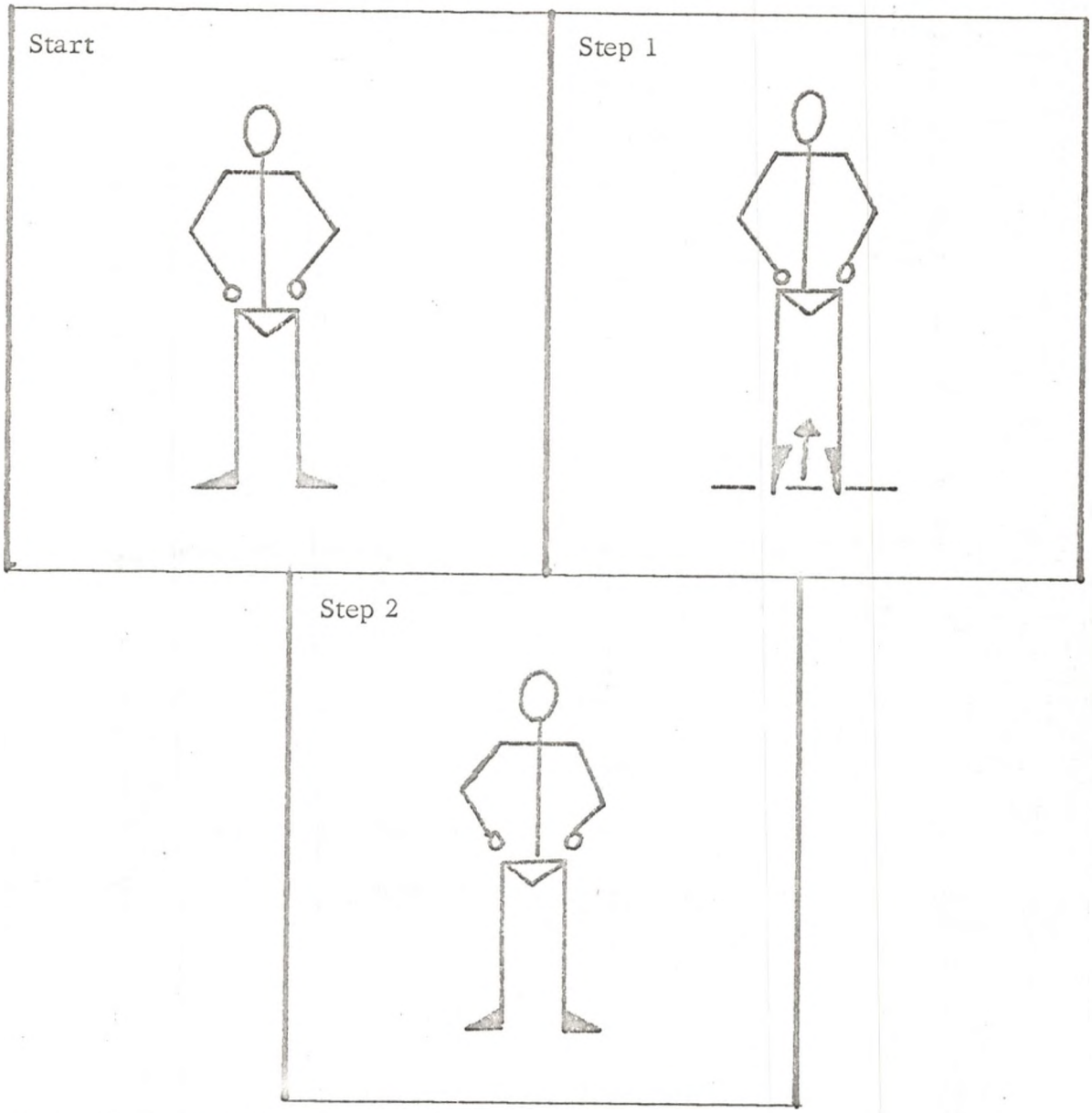



Figure 7 - Toe Raisers

Movement VII - Toe Raisers

Start: Standing position, hands on hips, feet shoulder width apart, toes pointing out at a 45 degree angle.

Step 1: Raise up on toes on signal.

Step 2: Lower heels to floor, repeat on count, eight (8) to sixteen (16) times.

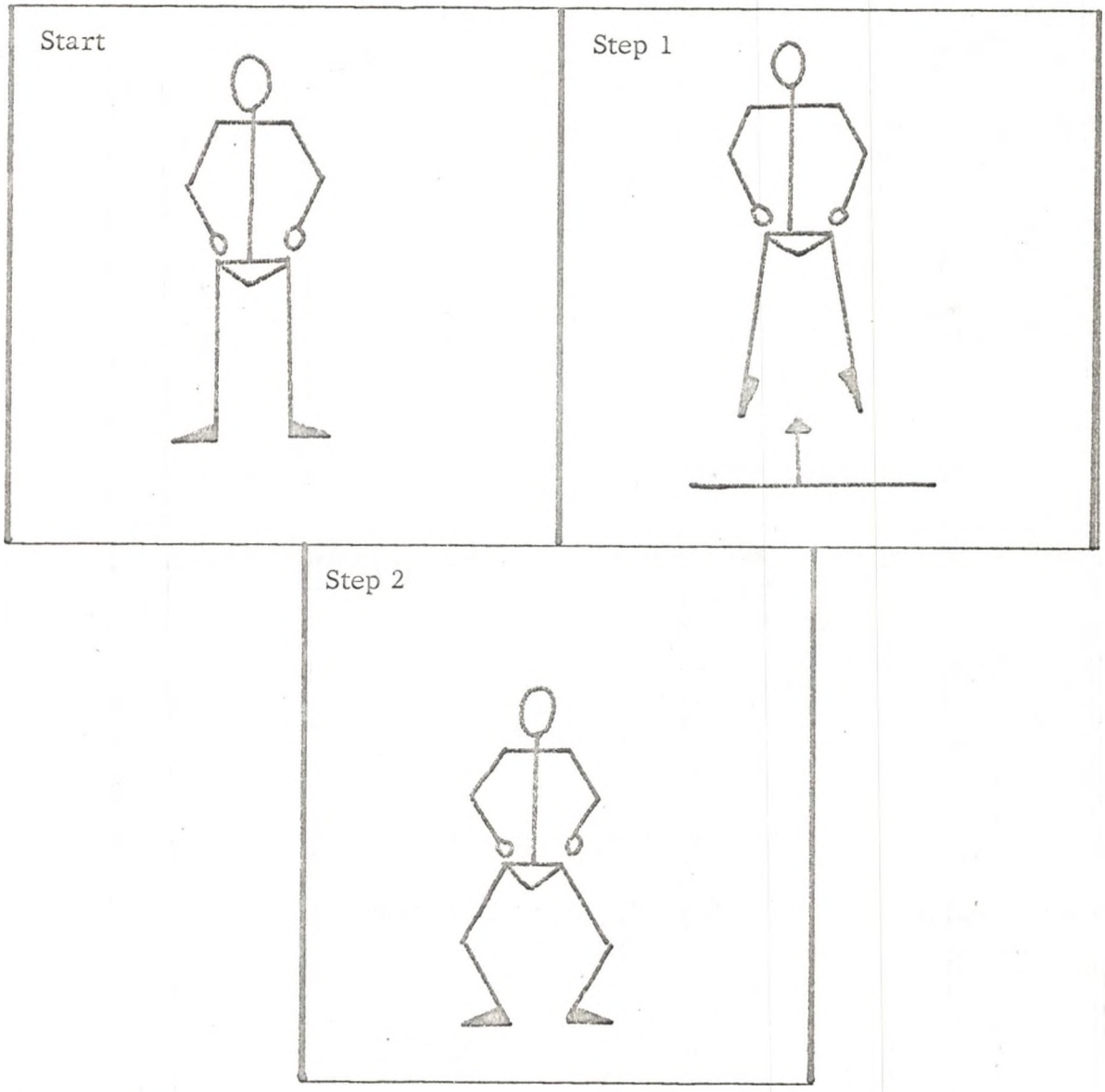



Figure 8 - Toe Springs

Movement VIII - Toe Springs

Start: Same position as in Movement VI.

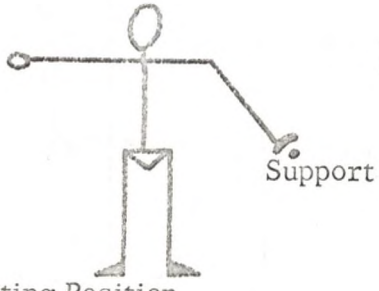
Step 1: Spring from balls of feet, flexing knees slightly.

Step 2: Land on floor, on balls of feet, let feet drop to heels, flex knees to absorb shock of floor - repeat eight to sixteen times (see Figure 8).

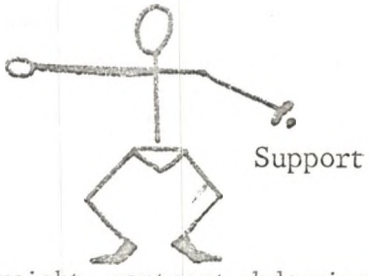
## E. Exercises with Bar Support[7]

Most of these exercises were with one hand on the bar or a strong ledge. They could also be done outdoors using a rail or fence for support. They were done with slow, deliberate movement, rather than with quick, jerky or tensing movements. Each exercise was performed on the leg away from the bar with an about face when alternating the other leg.

Exercise I




Starting Position
Figure 1




Back straight, contract abdominals, bend knees as far as possible, with both heels on floor. Figure 2

Lower heels to floor, keep knees bent as much as possible.
Figure 3

Heels on floor, straighten knees, keep balance on both feet, return to starting position. Figure 4

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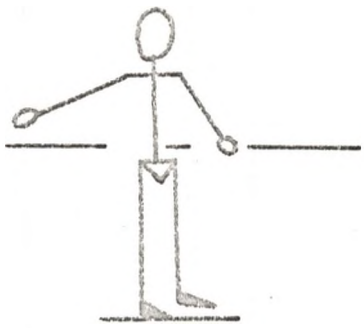
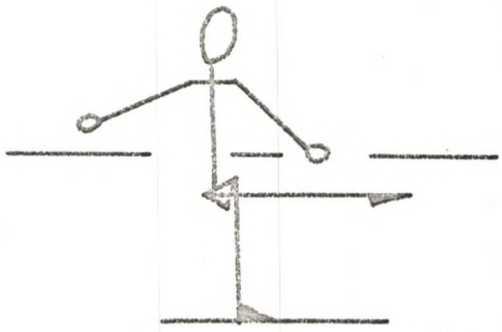
[7] Andrew Hardie, Ballet Exercises for Athletes (London: Amateur Athletic Association, 1961), pp. 3 - 24.

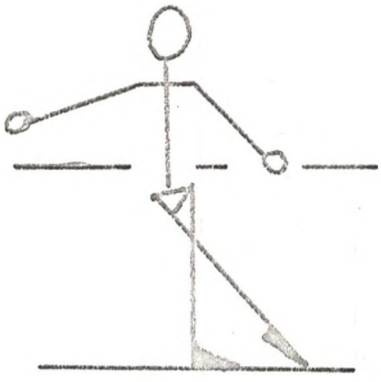
Exercise II



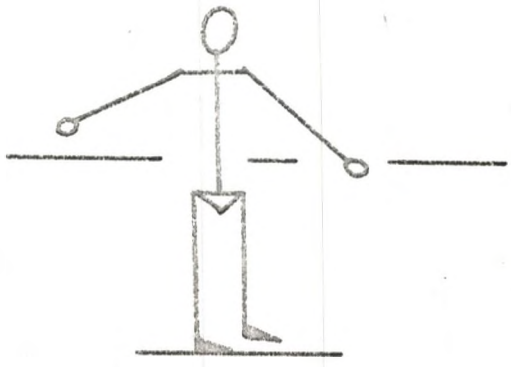
Starting position.
Figure 1



Beat thigh into air to horizontal position.
Figure 2



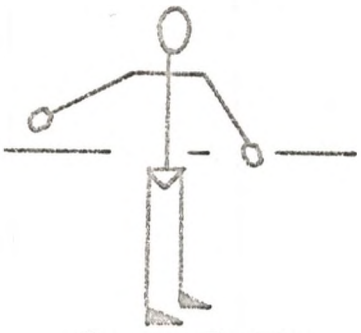
Bring feet down until tip of toe touches floor.
Figure 3



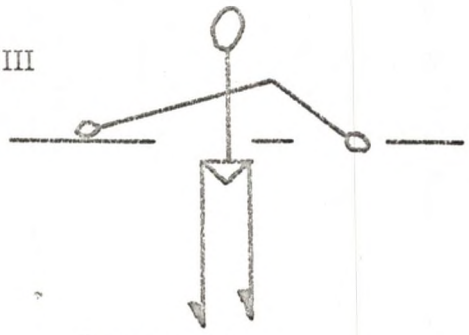
Return to starting position.
Figure 4

This exercise is also done to the side and back, maintaining the same position.

Exercise III

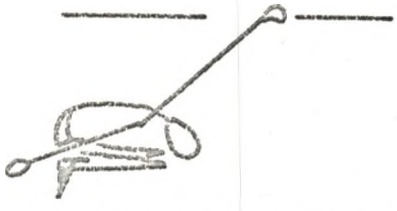


Starting Position
Figure 1



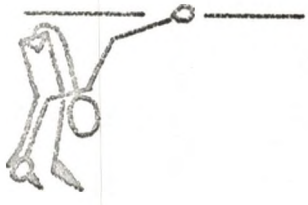
Raise on Toes
Figure 2

Sit down on heels
Figure 3

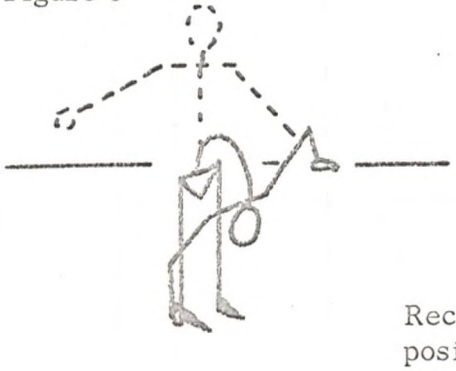


Place head on knees, keep knees firmly together.
Figure 4

Grip heel with free hand.
Figure 5

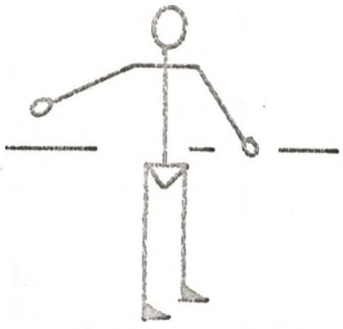


Slowly straighten knees. Do not remove head from knees if possible.
Figure 6

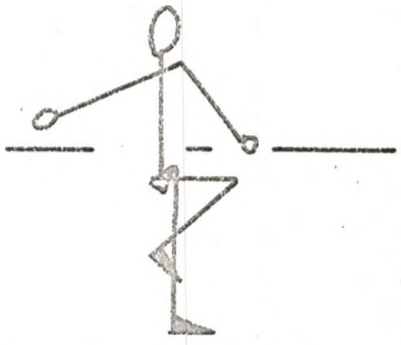


Recover slowly to starting position.
Figure 7

Exercise IV



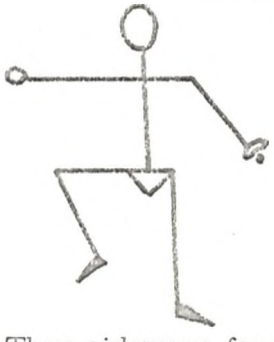
Starting position.
Figure 1



Thrust knee forcefully into air forward four times.
Figure 2

Then sideways four times.
Figure 3

Then backward four times.
Figure 4

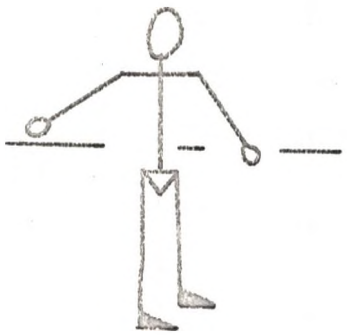


Then sideways four times.
Return to starting position.
Figure 5

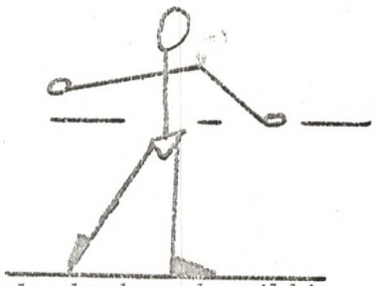
While this exercise was performed, the supporting leg was still and straight.

The hips remained still, except when thrusting backward.

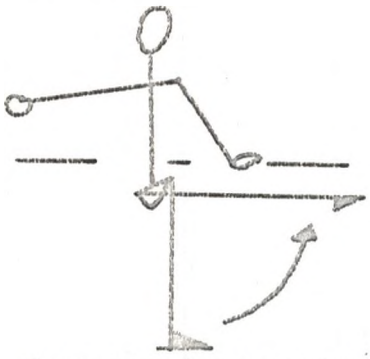
Exercise V



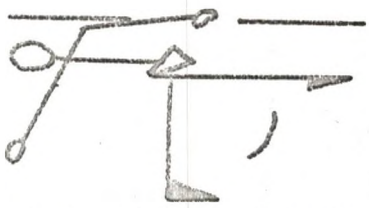
Starting position.
Figure 1



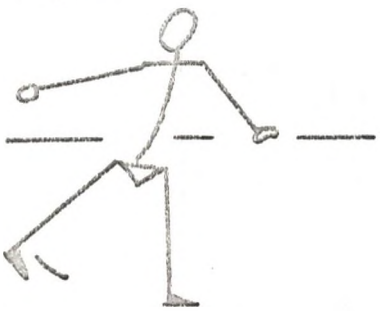
Stretch leg backward until big toe touches floor.
Figure 2



Repeat to sixteen swings forward, when leg reaches highest point forward.
Figure 3



Bend body forcefully backward, leg and body horizontal.
Figure 4

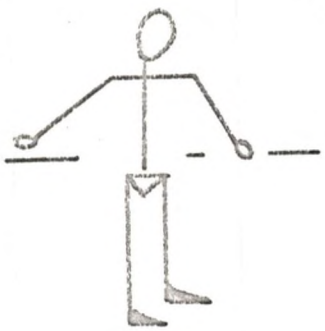


Thrust leg backward
Figure 5

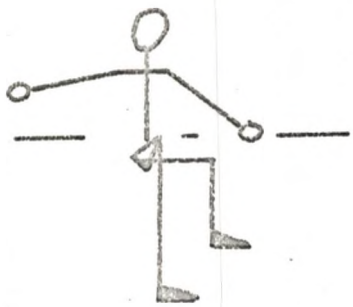
Bend body forward to horizontal - keep free arm in original position.
Figure 6

Maintain an even rhythm during this exercise. Allow no excessive speed.

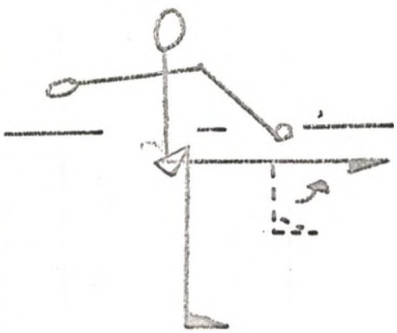
Exercise VI



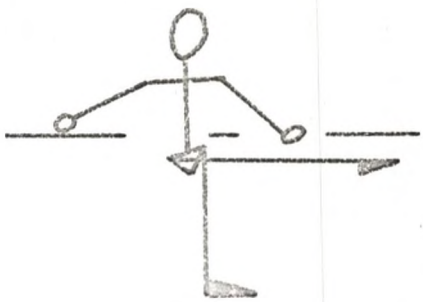
Starting position.
Figure 1



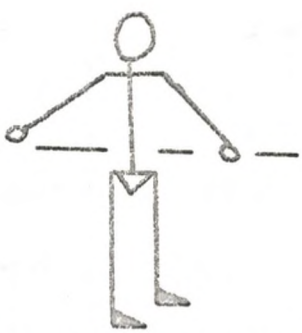
Raise knee forward to hip.
Figure 2



Maintain knee height, slowly straighten leg until fully stretched.
Figure 3



Arch foot in air - keep knee taut or locked.
Figure 4



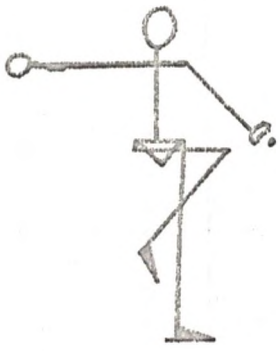
Return to starting position.
Figure 5

This exercise is also done to the side and back, keeping the hips stable and knee of supporting leg locked.

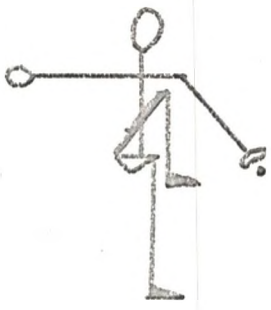
Exercise VII

Starting position.
Figure 1

Stretch leg to side with knee locked. Hold about twelve inches off the floor.
Figure 2

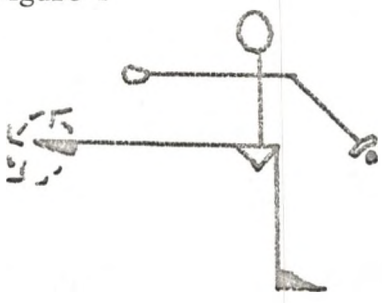


Turn leg inward and bend knee so thigh is across body.
Figure 3



Lift thigh so knee is almost at chest level.
Figure 4

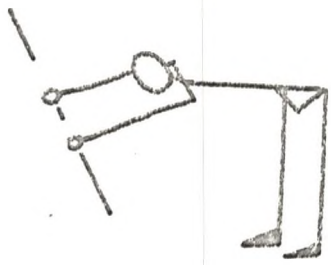
Open thigh sideways and ---
Figure 5



Extend leg, bring heel upward in line with knee. Rotate foot, keeping knee taut. Return to starting position.
Figure 6

Exercise VIII

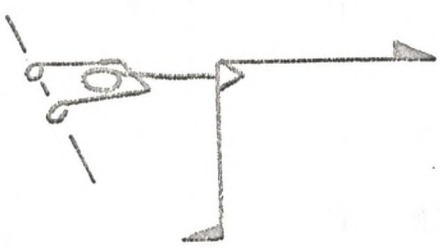
Starting position.
Figure 1



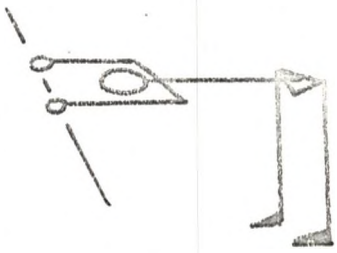
Face bar, holding it with both hands.
Figure 2

Pull away until arms and body are horizontal and legs vertical.
Figure 3

Release right foot slightly forward, and ---
Figure 4

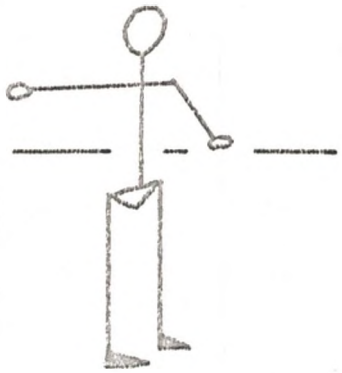


Thrust forcefully backward as far as possible. Keep both knees straight.
Figure 5

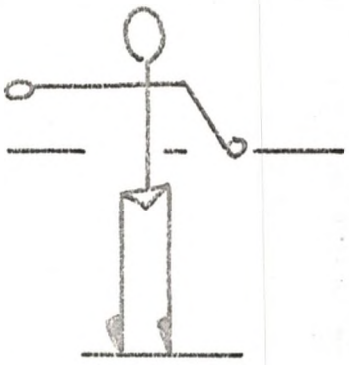


Return foot to ground. Repeat with left foot.
Figure 6

Exercise IX

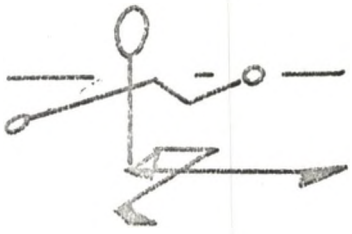


Starting position.
Figure 1

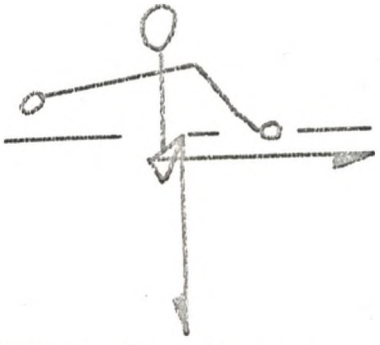


Raise both heels.
Figure 2

Maintain body in erect position. Sit down on heels.
Figure 3



Extend leg furthest from support until straight, about six inches from floor.
Figure 4



Without depending too much on support, raise upright on leg nearest support - return to starting position.
Figure 5

Exercise X

Starting position.
Figure 1

Sit down on heels.
Figure 2

Without returning to upright, press knees forward and bend back backward.
Figure 3

Press hips forward over knees - bend further backward.
Figure 4

Return to upright. Keep heels raised. Return to starting position.
Figure 5

# CHAPTER IV

## ANALYSIS OF THE DATA

### A. Statistical Procedure

The purpose of this study was to evaluate the change, if any, in flexibility between two groups of freshman college football players. An experimental group received an exercise program, while the control group received none. Both groups were tested to determine the degrees of flexibility and the amount of body balance in these two groups before the treatment, which only the experimental group received, and upon completion of the program.

This investigator selected the null hypothesis[1] as a means of analyzing the significance of the difference between the means of these groups. This hypothesis asserts that there is no true difference between two population means, and that the difference found between sample means is, therefore, accidental and unimportant. In determining the intragroup significance, the significance of the difference between the means of the initial test and the re-test was determined with the "t" test for significance. The "t" ratio showed, as a result of dividing the actual mean difference by the standard error of the mean, the level of significance established in the "t" table. To determine at what level the "t" ratio fell, the formula (N-1) was applied to find the degrees

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[1] Henry E. Garret, Statistics in Psychology and Education (New York: Longsmans, Green and Company, Fifth Edition, 1958), p. 213.

of freedom for the intragroup comparison. The level of significance assumed by this investigator, after computation of the data and consultation with his committee, was at the .05 level.

In determining the significance of the mean difference in intergroup, or between group comparison, the formula for the degrees of freedom establishing the .05 level of significance in the "t" table was $(N_1 + N_2 - 3)$. In both comparisons the null hypothesis was accepted or rejected according to the "t" ratio and level of significance established.

The sources referred to in the selection of the proper formulae used in this study were those of Edwards[2] and Garret[3]. This investigator, through the guidance of his committee, felt the formulae selected from these two sources were best adapted to this study.

## B. Results of Comparison

The intragroup comparison, or within group comparison, established the significance of the difference between the means. This was computed by comparison of the results of the initial test and the retest within each group in the movement tested.

The intergroup comparison established the significance of the difference between the means of the retest results between the experimental and control groups in the movement tested. This was calculated by the use of the formula

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[2] Edwards, op.cit., pp. 252 - 282.

[3] Garret, op.cit., pp. 214 - 215.

for establishing the standard error of the difference between means for equated groups.[4]

Trunk and Hip Flexion

The experimental group mean score on the initial test of 146.2 degrees and the mean score of 148.8 degrees on the retest, produced a mean difference of 2.6 degrees for both tests. The "t" value of 1.92 for the experimental group fell below the 2.06 level of criterion for 14 degrees of freedom at the .05 level. The null hypothesis was accepted.

The control group had a mean of 145.5 degrees on the initial test and a mean of 144.9 degrees on the retest. The mean difference as a result was -.923 degrees, for the two tests. The value for "t" was computed as -.632. For 12 degrees of freedom the criterion at the .05 level was 2.18. The null hypothesis was accepted for the control group, since this decrease was not significant.

The between groups comparison showed that the experimental group and control group retest mean score difference was 3.90 degrees. The "t" value of the two groups was 1.11. The 25 degrees of freedom established "t" at the .05 level of 2.06. Consequently, the null hypothesis was accepted.

Trunk and Hip Extension

The mean of the experimental group in the initial test was 41.8 degrees. The mean of the retest was 50.6 degrees. The mean difference between the two

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[4] Edwards, op.cit., pp. 282 - 288.

tests was 8.73 degrees. The experimental group had a "t" ratio of 3.96. At the .05 level of significance "t" equals 2.14 for 14 degrees of freedom. The null hypothesis was rejected for the experimental group since 3.96 was significant at the .05 level.

The control group produced a mean of the initial test of 49.5 degrees and a mean of 52.7 degrees on the retest. The mean score difference between the two tests was 3.15 degrees. For 12 degrees of freedom "t" equaled 3.06 at the .05 level. Since "t" of the control group was 4.39, the null hypothesis was also rejected for the control group.

In the between group, or intergroup comparison, for trunk and hip extension, the difference between the experimental group retest mean and control group retest mean was 2.00 degrees. The significance of the difference determined by the "t" ratio was .791. The "t" value for 25 degrees of freedom at the .05 level was 2.06. Therefore, the null hypothesis was accepted.

### Stork Stand Test for Balance

The initial test mean for the experimental group was 6.7 points, and the mean score for the retest was 8.0 points. The experimental group had a mean score difference of 1.26 points. After computation of the "t" value, which was 2.00, the criterion of 2.14 for 14 degrees of freedom showed no significance at the .05 level. The null hypothesis was accepted.

The control group had a mean of 7.7 points on the initial test and 7.0 points on the retest. A mean difference of a -.846 points, when used in computing the "t" value, resulted in a "t" value of -8.85. The value of "t" at

.05 level for 12 degrees of freedom was 2.18. Consequently, the null hypothesis was rejected. This "t" value produced a significant decrease by the control group.

When computing the significance of the difference between the mean of the retests of the two groups, a mean score difference of 1.00 points resulted. This figure applied in the formula produced a "t" value of .870 which was not significant at the .05 level. The value of "t" with 25 degrees of freedom at the .05 level was 2.06. Therefore, the null hypothesis was accepted.

Right Leg Abduction

The experimental group mean on the initial test was 54.6 degrees of flexibility, which the retest mean showed 56.8 degrees. The mean score difference was 2.26 degrees. The "t" ratio of 3.24 was significant at the .05 level. With 14 degrees of freedom, "t" was 2.14. The null hypothesis was rejected.

Control group results on the initial test showed a mean of 53.2 degrees, and the retest mean was 55.2 degrees of flexibility. The control group mean difference was 2.00 degrees. The "t" value for these two tests was 4.61, significant at the .05 level of significance for 12 degrees of freedom. The null hypothesis was rejected.

Intergroup results of the significance of the difference between the means of the retests showed a mean difference between the experimental group mean and control group retest means of 1.60 degrees. The "t" value was not significant at the .05 level, since a criterion of 2.06 was needed. The "t" value

for 25 degrees of freedom was .560. As a result, the null hypothesis was accepted.

Left Leg Abduction

The experimental group mean score was 52.5 degrees of movement on the initial test. The retest mean was 56.8 degrees. The two tests showed 4.33 degrees of difference between the initial and retest means. A "t" value of 4.13 was significant at the .05 level for 14 degrees of freedom. The null hypothesis was therefore rejected.

The control group results produced a mean of 54.2 degrees on the initial test and a mean of 53.3 degrees on the retest. The mean difference of -1.61 degrees between the two tests, when used in the "t" ratio, resulted in a value for "t" of -5.29 degrees. Although a negative number, this was significant at the .05 level of significance with 12 degrees of freedom. This "t" value is, therefore, a significant decrease. As a result, the null hypothesis was rejected.

Between the experimental and control groups the difference of the retest means was 3.60 degrees. The "t" value was 1.81, not significant at the .05 level for 25 degrees of freedom. Therefore, the null hypothesis was accepted since "t" at the .05 level was 2.06 according to the table for "t".

The raw scores, mathematical procedure and formulae used in computing the within group results are recorded in Appendix B. The results of the comparison made with the retest means are recorded in Appendix C.

TABLE 1

MEAN SCORES IN TESTS OF SUBJECTS IN EXPERIMENTAL GROUP

| Name of Test | Number | Initial Test | Retest |
|---|---|---|---|
| Trunk and Hip Flexion | 15 | 146.2 | 148.8 |
| Trunk and Hip Extension | 15 | 41.8 | 50.6 |
| Stork Stand Test for Balance | 15 | 6.7 | 8.0 |
| Right Leg Abduction | 15 | 54.6 | 56.8 |
| Left Leg Abduction | 15 | 52.5 | 56.8 |

MEAN SCORES IN TESTS OF SUBJECTS IN CONTROL GROUP

| Name of Test | Number | Initial Test | Retest |
|---|---|---|---|
| Trunk and Hip Flexion | 13 | 145.5 | 144.9 |
| Trunk and Hip Extension | 13 | 49.5 | 52.7 |
| Stork Stand Test for Balance | 13 | 7.7 | 7.0 |
| Right Leg Abduction | 13 | 53.2 | 55.2 |
| Left Leg Abduction | 13 | 54.2 | 53.3 |

TABLE 2

"t" AND THE SIGNIFICANCE OF DIFFERENCE IN INTRAGROUP COMPARISON

| Area of Comparison | "t" Value of Experimental Group | "t" Value of Control Group |
|---|---|---|
| Trunk and Hip Flexion | 1.92 not significant | -.632 not significant decrease |
| Trunk and Hip Extension | 3.96 significant | 4.39 significant |
| Stork Stand Test for Balance | 2.00 not significant | -8.85 significant decrease |
| Right Leg Abduction | 3.24 significant | 4.61 significant |
| Left Leg Abduction | 4.13 significant | -5.29 significant decrease |

"t" AND THE SIGNIFICANCE OF DIFFERENCE IN INTERGROUP COMPARISON

| Area of Comparison | "t" Value of Mean Difference Between Retests of Experimental and Control Groups |
|---|---|
| Trunk and Hip Flexion | 1.11 not significant |
| Trunk and Hip Extension | .791 not significant |
| Stork Stand Test for Balance | .870 not significant |
| Right Leg Abduction | .560 not significant |
| Left Leg Abduction | 1.81 not significant |

# CHAPTER V

## SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

### A. Summary

This study was undertaken to determine the effects of modern dance upon body balance and flexibility in freshman college football players. Five areas were tested in an attempt to determine the changes, if any, in trunk and hip flexion and extension, leg abduction and body balance. The Leighton Flexometer was used to measure body flexibility. The stork stand test for balance was administered to determine body balance.

Two groups were selected from a total population of 35 freshman football players at the University of North Dakota. An experimental group of 15 subjects and a control group of 13 subjects volunteered to participate in this study. The experimental group enrolled in a physical education service class, which met twice weekly for 12 weeks for a period of 60 minutes. This group received an exercise program of modern dance movement. The control group was enrolled in other physical education classes and received no modern dance exercise. Both groups were tested at the beginning and the end of the experimental period. The raw scores were used from the initial and retest of both groups. These scores were computed by determining the significance of

the difference between the means of the initial and retests with each group. A between group comparison was made by use of the formula for determining the standard error of the difference between means for equated groups. This determined the significance of the difference between the means of the retests of each group. The null hypothesis was assumed in testing the significance of difference between means at the .05 level of confidence.

## B. Findings

1. In the area of trunk and hip flexion, in the within group comparison, the experimental group and control groups produced "t" values not significant at the .05 level. However, the control group "t" value was a negative number, considerably below the "t" value of the experimental group. This bears evidence for a significant decrease by the control group.

2. The test for flexibility in hip and trunk extension produced significant "t" values at the .05 level in both groups in the within group comparison.

3. The stork stand test for balance, in intragroup comparison, produced "t" values below the .05 level in both experimental and control groups. The control group "t" value resulted in a negative value, much below the "t" value produced by the experimental group, which is a significant decrease by the control group.

4. The right leg abduction test produced significant "t" values to the .05 level in both groups tested in within group comparison.

5. In the left leg abduction test, the experimental group produced a "t"

value significant at the .05 level. The control group "t" value resulted in a negative number, much below the .05 level of significance. This is evident of a significant decrease by the control group.

6. In the intergroup (between group) comparison, all areas tested produced "t" values below the .05 level.

## C. Conclusions

1. It can be concluded that trunk and hip flexion was increased due to modern dance movement as shown by the data produced in the intragroup comparison. This may be due to the decrease produced by the control group.

2. Trunk and hip extension may not have increased as shown by the results of the between group and within group comparisons. The within group produced "t" values at the .05 level. The between group comparison produced a non-significant "t" value.

3. It would seem possible to conclude that body balance was also increased as a result of the modern dance exercise. This was shown in the analysis of the data in the within group comparison.

4. Right leg abduction flexibility increases were not evident as shown by the two comparisons. It was assumed that this might be due to the subjects being "right legged". Use of the right leg more frequently in activities performed may have produced this effect.

5. It was concluded that flexibility was increased in left leg abduction by participation in modern dance exercises. This is very evident as shown by the intragroup comparison. The significant decrease by the control group may

bear evidence to this conclusion.

6. It would seem possible to conclude that modern dance movement can improve the flexibility of college football players, at least in the areas tested in this study. It can also be concluded that body balance may be improved through this type of program in freshman college football players.

## D. Discussion

The results of this study have produced sufficient evidence for this investigator to conclude that body flexibility and balance in college freshman football players can be increased through the administration of modern dance exercises.

Although the results of the between group comparison are not highly significant in all areas, the results of the within group comparisons established some significant results. Two tests of flexibility produced significant decreases within the control groups of the areas tested, while the experimental groups produced scores which may appear to be increases, although not significant at the .05 level. A significant decrease also was produced by the control group in the test for body balance. The experimental group, in this test, produced a score not at the .05 level which appears to be a non-significant increase.

The two remaining areas of flexibility produced no significant values. This may be due to the length of the exercise period. More intense and numerous periods of exercise may have produced more significant results in these areas.

Since this investigator is an ex-college football player who participated

in the experimental group exercise program, he can bear personal evidence of the increase in body flexibility and balance. He found his own flexibility and body balance was increased upon completing participation in this study.

## E. Recommendations

Since this study was limited to four areas of body flexibility, this investigator recommends a more intense and continuous study with the use of Leighton's flexibility movements. His design of flexibility movements could evaluate the anatomical regions more accurately and closely.

It is also recommended that a study be conducted which would control the subjects of both groups more closely. The experimental group should receive only modern dance exercises and receive nothing in the area of football conditioning. This might curtail the possibility of decreasing any flexibility which would be gained by the experimental group in modern dance exercise. If possible, the control group should not be allowed to participate in any extra physical activity.

It would seem that participation in a modern dance program, which met for a full hour, five times a week, might be more effective. This amount of participation could well result in a more significant increase in flexibility and body balance. Continuing the program throughout the summer and winter months would also seem feasible.

This investigator continued observation of the subjects that participated in the study throughout the following spring practice. It would seem that the likelihood of injury could be reduced through the use of this program, since the

experimental group subjects were not injured seriously in areas of muscle strain or pull. The stretching and tensing effect of the modern dance routine may well have strengthened muscle fibers sufficiently to prevent pull or strain which could have resulted in disabling injury. For this reason, if no other, it is recommended the modern dance exercises be used in the conditioning program of football players.

Since this investigator is an ex-college football player and participated in the experimental group program, he recommends modern dance as a program for improving the flexibility, body balance and physical condition in college football players. This investigator found the modern dance program improved his own flexibility and physical condition, in terms of better muscle tone.

# APPENDIX A

# FORMULAE USED IN EQUATING THE GROUPS

## SIGNIFICANCE OF THE DIFFERENCE BETWEEN TWO MEANS FOR UNCORRELATED GROUPS

$S_{\bar{X}_1 - \bar{X}_2}$ = (Standard error of the difference between two means)

$$S_{\bar{X} - \bar{X}_2} = \sqrt{\left(\frac{\Sigma x_1^2 + \Sigma x_2^2}{N_1 + N_2 - 2}\right)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$\Sigma x_1^2 = \Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1}$$

$$\Sigma x_2^2 = \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2}$$

$$\text{"t"} = \frac{\bar{X}_1 - \bar{X}_2}{S_{\bar{X}_1 - \bar{X}_2}}$$

# SIGNIFICANCE OF THE DIFFERENCE BETWEEN TWO MEANS FOR UNCORRELATED GROUPS

## EQUATION OF STORK STAND

| | Experimental Group Initial Test | | Control Group Initial Test | |
|---|---|---|---|---|
| | $X_1$ | $X_1^2$ | $X_2$ | $X_2^2$ |
| 1. | 10 | 100 | 10 | 100 |
| 2. | 9 | 81 | 10 | 100 |
| 3. | 4 | 16 | 10 | 100 |
| 4. | 5 | 25 | 5 | 25 |
| 5. | 5 | 25 | 8 | 64 |
| 6. | 1 | 1 | 10 | 100 |
| 7. | 10 | 100 | 1 | 1 |
| 8. | 4 | 16 | 10 | 100 |
| 9. | 10 | 100 | 3 | 9 |
| 10. | 10 | 100 | 8 | 64 |
| 11. | 5 | 25 | 8 | 64 |
| 12. | 8 | 64 | 9 | 81 |
| 13. | 4 | 16 | 9 | 81 |
| 14. | 6 | 36 | | |
| 15. | 10 | 100 | | |
| | 101 | 805 | 101 | 889 |

Mean score ($\overline{X}_1$) of $X_1$ = 6.7

Mean score ($\overline{X}_2$) of $X_2$ = 7.7

# SIGNIFICANCE OF THE DIFFERENCE BETWEEN TWO MEANS FOR UNCORRELATED GROUPS

EQUATION OF STORK STAND

$$\Sigma x_1^2 = 805 - \frac{(101)^2}{15}$$

$$\Sigma x_1^2 = 125$$

$$\Sigma x_2^2 = 889 - \frac{(101)^2}{13}$$

$$\Sigma x_2^2 = 104$$

$$S_{\bar{X}_1 - \bar{X}_2} = \sqrt{\left(\frac{125 + 104}{15 + 13 - 2}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S_{\bar{X}_1 - \bar{X}_2} = 1.126$$

$$\text{"t"} = \frac{6.7 - 7.7}{1.126} \qquad \text{"t"} = \underline{\underline{.888}}$$

$$df = N_1 + N_2 - 2 = 26$$

"t" at .05 level = 2.06 Not significant at .05 level

## SIGNIFICANCE OF THE DIFFERENCE BETWEEN TWO MEANS FOR UNCORRELATED GROUPS

### EQUATION OF TRUNK AND HIP FLEXION

| | Experimental Group Initial Test | | Control Group Initial Test | |
|---|---|---|---|---|
| | $X_1$ | $X_1^2$ | $X_2$ | $X_2^2$ |
| 1. | 154 | 23,716 | 146 | 21,316 |
| 2. | 160 | 25,600 | 129 | 16,641 |
| 3. | 153 | 23,409 | 153 | 23,409 |
| 4. | 135 | 18,225 | 168 | 28,224 |
| 5. | 134 | 17,956 | 135 | 18,225 |
| 6. | 155 | 24,025 | 150 | 22,500 |
| 7. | 146 | 21,316 | 130 | 16,900 |
| 8. | 134 | 17,956 | 140 | 19,600 |
| 9. | 137 | 18,769 | 142 | 20,164 |
| 10. | 150 | 22,500 | 178 | 31,684 |
| 11. | 155 | 24,025 | 136 | 18,496 |
| 12. | 158 | 24,964 | 155 | 24,025 |
| 13. | 131 | 17,161 | 130 | 16,900 |
| 14. | 156 | 24,336 | 1,892 | 278,084 |
| 15. | 135 | 18,225 | | |
| | 2,193 | 322,183 | | |

Mean score ($\bar{X}_1$) of $X_1$ = 146.2

Mean score ($\bar{X}_2$) of $X_2$ = 145.5

## SIGNIFICANCE OF THE DIFFERENCE BETWEEN TWO MEANS FOR UNCORRELATED GROUPS

### EQUATION OF TRUNK AND HIP FLEXION

$$\Sigma x_1^2 = 322,183 - \frac{(2193)^2}{15}$$

$$\Sigma x_1^2 = 1566.4$$

$$\Sigma x_2^2 = 278,084 - \frac{(1892)^2}{13}$$

$$\Sigma x_2^2 = 2725.2$$

$$S_{\bar{X}_1 - \bar{X}_2} = \sqrt{\left(\frac{1566.4 + 2725.2}{15 + 13 - 2}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S_{\bar{X}_1 - \bar{X}_2} = 4.876$$

$$\text{"t"} = \frac{146.2 - 145.5}{4.876} = \text{"t"} = \underline{\underline{.143}}$$

$df = 15 + 13 - 2 = 26$

"t" at .05 level = 2.06 Not significant at .05 level

# APPENDIX B

INITIAL TEST AND RETEST OF CONTROL GROUP
IN TRUNK AND HIP FLEXION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 146 | 141 | - 5 | 25 |
| 2. | 126 | 128 | - 1 | 1 |
| 3. | 153 | 133 | -20 | 400 |
| 4. | 168 | 165 | - 3 | 9 |
| 5. | 135 | 138 | 3 | 9 |
| 6. | 150 | 156 | 6 | 36 |
| 7. | 130 | 123 | - 7 | 49 |
| 8. | 140 | 138 | - 2 | 4 |
| 9. | 142 | 144 | - 2 | 4 |
| 10. | 178 | 195 | 17 | 289 |
| 11. | 136 | 135 | - 1 | 1 |
| 12. | 155 | 158 | 3 | 9 |
| 13. | 130 | 130 | 0 | 0 |
| | 1892 | 1884 | -12 | 836 |

| | |
|---|---|
| Mean Score of Initial Test | 145.5 |
| Mean Score of Retest | 144.9 |
| Sum of Differences | -12 |
| Sum of Differences Squared | 836 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Trunk and Hip Flexion GROUP Control

$N = 13$

$D = -12$

$D^2 = 836$

$S_{\bar{D}}$ (estimate of the sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \frac{\sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}}}{\sqrt{N}} = \frac{\sqrt{\frac{836 - \frac{(-12)^2}{13}}{12}}}{\sqrt{13}}$$

$S_{\bar{D}} = .584$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{-12}{13} = -.923$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{.584}{.923} = \text{"t"} = \underline{\underline{-.632}}$$

df = N-1 = 12

"t" at .05 level = 2.18

Not significant at .05 level

INITIAL TEST AND RETEST OF EXPERIMENTAL GROUP IN TRUNK AND HIP FLEXION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 154 | 149 | - 5 | 25 |
| 2. | 160 | 165 | 5 | 25 |
| 3. | 153 | 150 | - 3 | 9 |
| 4. | 135 | 133 | - 2 | 4 |
| 5. | 134 | 136 | 2 | 4 |
| 6. | 155 | 150 | - 5 | 25 |
| 7. | 146 | 148 | 2 | 4 |
| 8. | 134 | 156 | 22 | 484 |
| 9. | 137 | 139 | 2 | 4 |
| 10. | 150 | 135 | -15 | 225 |
| 11. | 155 | 156 | 1 | 1 |
| 12. | 158 | 165 | 7 | 49 |
| 13. | 131 | 146 | 15 | 225 |
| 14. | 156 | 150 | - 6 | 36 |
| 15. | 135 | 154 | 19 | 361 |
| | 2193 | 2232 | 39 | 1481 |

| | |
|---|---|
| Mean Score of Initial Test | 146.2 |
| Mean Score of Retest | 148.8 |
| Sum of Differences | 39 |
| Sum of Differences Squared | 1481 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Trunk and Hip Flexion GROUP Experimental

$N = 15$

$D = 49$

$D^2 = 1481$

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{1481 - \frac{(49)^2}{15}}{14}}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{15}}$$

$S_{\bar{D}} = 1.699$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{39}{15} = 2.6$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{3.266}{1.699} = \text{"t"} = \underline{\underline{1.92}}$$

df = N-1 = 14

"t" at .05 level = 2.18

Not significant at .05 level

INITIAL TEST AND RETEST OF CONTROL GROUP
IN TRUNK AND HIP EXTENSION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 43 | 60 | 17 | 289 |
| 2. | 44 | 42 | - 2 | 4 |
| 3. | 45 | 62 | 17 | 289 |
| 4. | 74 | 71 | - 3 | 9 |
| 5. | 63 | 61 | - 2 | 4 |
| 6. | 45 | 48 | 3 | 9 |
| 7. | 40 | 42 | 2 | 4 |
| 8. | 30 | 33 | 3 | 9 |
| 9. | 43 | 42 | - 1 | 1 |
| 10. | 55 | 58 | 3 | 9 |
| 11. | 50 | 51 | 1 | 1 |
| 12. | 59 | 60 | 1 | 1 |
| 13. | 53 | 55 | 2 | 4 |
| | 644 | 685 | 41 | 633 |

| | |
|---|---|
| Mean Score of Initial Test | 49.5 |
| Mean Score of Retest | 52.7 |
| Sum of Differences | 41 |
| Sum of Differences Squared | 633 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Trunk and Hip Extension GROUP Control

$N = 13$

$D = 41$

$D^2 = 633$

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$S_{\bar{D}} = \frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \frac{\sqrt{633 - \frac{(41)^2}{13}}}{\sqrt{12}}$$

$$\frac{}{\sqrt{N}} \qquad \frac{}{\sqrt{12}}$$

$S_{\bar{D}} = .718$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{41}{13} = 3.153$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{3.153}{.718} = \text{"t"} = \underline{\underline{4.39}}$$

df = N-1 = 12

"t" at .05 level = 2.18

Significant at .05 level

INITIAL TEST AND RETEST OF EXPERIMENTAL GROUP IN TRUNK AND HIP EXTENSION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 45 | 61 | 16 | 256 |
| 2. | 39 | 57 | 18 | 324 |
| 3. | 42 | 56 | 14 | 196 |
| 4. | 30 | 40 | 10 | 100 |
| 5. | 35 | 45 | 10 | 100 |
| 6. | 43 | 46 | 3 | 9 |
| 7. | 51 | 50 | - 1 | 1 |
| 8. | 33 | 34 | 1 | 1 |
| 9. | 38 | 56 | 18 | 324 |
| 10. | 32 | 44 | 12 | 144 |
| 11. | 55 | 63 | 8 | 64 |
| 12. | 56 | 69 | 13 | 169 |
| 13. | 33 | 34 | 1 | 1 |
| 14. | 46 | 49 | 3 | 9 |
| 15. | 50 | 55 | 5 | 25 |
| | 628 | 759 | 131 | 1721 |

| | |
|---|---|
| Mean Score of Initial Test | 41.8 |
| Mean Score of Retest | 50.6 |
| Sum of Differences | 131 |
| Sum of Differences Squared | 1721 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Trunk and Hip Extension GROUP Experimental

$N = 15$

$D = 131$

$D^2 = 1721$

$S_{\bar{D}}$ = (estimate of the sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{1721 - \frac{(131)^2}{15}}{14}}$$

$$\sqrt{N} \qquad \sqrt{15}$$

$S_{\bar{D}} = 2.213$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{131}{15} = 8.733$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{8.733}{2.213} = \text{"t"} = \underline{\underline{3.96}}$$

df = N-1 = 14

"t" at .05 level = 2.14

Significant at .05 level

INITIAL TEST AND RETEST OF THE CONTROL GROUP IN THE STORK STAND

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 10 | 5 | - 5 | 25 |
| 2. | 10 | 2 | - 8 | 64 |
| 3. | 10 | 10 | 0 | 0 |
| 4. | 5 | 4 | - 1 | 1 |
| 5. | 8 | 4 | - 4 | 16 |
| 6. | 10 | 10 | 0 | 0 |
| 7. | 1 | 10 | 9 | 81 |
| 8. | 10 | 10 | 0 | 0 |
| 9. | 3 | 2 | - 1 | 1 |
| 10. | 8 | 10 | - 2 | 4 |
| 11. | 8 | 9 | 1 | 1 |
| 12. | 9 | 8 | - 1 | 1 |
| 13. | 9 | 8 | - 1 | 1 |
| | 101 | 92 | -13 | 195 |

| | |
|---|---|
| Mean Score of Initial Test | 7.7 |
| Mean Score of Retest | 7.0 |
| Sum of Differences | -13 |
| Sum of Differences Squared | 195 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Stork Stand GROUP Control

N = 13

D = -11

$D^2$ = 195

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{195 - \frac{(-13)^2}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = .113

$\bar{D} = \frac{\Sigma D}{N} = \frac{-13}{13} = -1.00$ "t" = $\frac{\bar{D}}{S_{\bar{D}}}$ =

"t" = -8.85

df = N-1 = 12

"t" at .05 level = 2.18

Significant at .05 level significant decrease

INITIAL TEST AND RETEST OF EXPERIMENTAL GROUP IN THE STORK STAND

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 10 | 10 | 0 | 0 |
| 2. | 9 | 3 | - 6 | 36 |
| 3. | 4 | 3 | - 1 | 1 |
| 4. | 5 | 7 | 2 | 4 |
| 5. | 5 | 10 | 5 | 25 |
| 6. | 1 | 10 | 9 | 81 |
| 7. | 10 | 10 | 0 | 0 |
| 8. | 4 | 4 | 0 | 0 |
| 9. | 10 | 10 | 0 | 0 |
| 10. | 10 | 5 | - 5 | 25 |
| 11. | 5 | 10 | 5 | 25 |
| 12. | 8 | 10 | 2 | 4 |
| 13. | 4 | 9 | 5 | 25 |
| 14. | 6 | 9 | 3 | 9 |
| 15. | 10 | 10 | 0 | 0 |
| | 101 | 120 | 19 | 235 |

| | |
|---|---|
| Mean Score of Initial Test | 6.7 |
| Mean Score of Retest | 8.0 |
| Sum of Differences | 19 |
| Sum of Differences Squared | 235 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Stork Stand GROUP Experimental

N = 15

D = 19

$D^2$ = 235

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \sqrt{\frac{235 - \frac{(19)^2}{15}}{14}}$$

$$\sqrt{N} \qquad \sqrt{15}$$

$S_{\bar{D}}$ = 0.632

$$\bar{D} = \frac{\Sigma D}{N} = \frac{19}{15} = 1.266$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{1.266}{0.632} = \text{"t"} = \underline{\underline{2.00}}$$

df = N-1 = 14

"t" at .05 level = 2.14

Not significant at .05 level

INITIAL TEST AND RETEST OF CONTROL GROUP IN RIGHT LEG ABDUCTION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 50 | 57 | 7 | 49 |
| 2. | 45 | 46 | 1 | 1 |
| 3. | 46 | 59 | 13 | 169 |
| 4. | 59 | 59 | 0 | 0 |
| 5. | 50 | 50 | 0 | 0 |
| 6. | 44 | 52 | 8 | 64 |
| 7. | 50 | 48 | - 2 | 4 |
| 8. | 46 | 45 | - 1 | 1 |
| 9. | 57 | 58 | 1 | 1 |
| 10. | 45 | 45 | 0 | 0 |
| 11. | 66 | 67 | 1 | .1 |
| 12. | 68 | 68 | 0 | 0 |
| 13. | 66 | 64 | - 2 | 4 |
| | 692 | 718 | 26 | 294 |

| | |
|---|---|
| Mean Score of Initial Test | 53.2 |
| Mean Score of Retest | 55.2 |
| Sum of Differences | 26 |
| Sum of Differences Squared | 294 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Right Leg Abduction GROUP Control

N = 13

D = 26

$D^2$ = 294

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{294 - \frac{676}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = .433

$$\bar{D} = \frac{\Sigma D}{N} = \frac{26}{13} = 2.00$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{2.00}{.433} = \text{"t"} = \underline{\underline{4.61}}$$

df = N-1 = 12

"t" at .05 level = 2.18

Significant at .05 level

INITIAL TEST AND RETEST OF EXPERIMENTAL GROUP IN RIGHT LEG ABDUCTION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 52 | 56 | 4 | 16 |
| 2. | 55 | 66 | 11 | 121 |
| 3. | 75 | 69 | - 6 | 36 |
| 4. | 41 | 43 | 2 | 4 |
| 5. | 43 | 68 | 25 | 625 |
| 6. | 57 | 50 | - 7 | 49 |
| 7. | 54 | 48 | - 6 | 36 |
| 8. | 47 | 50 | 3 | 9 |
| 9. | 49 | 55 | 6 | 36 |
| 10. | 44 | 54 | 10 | 100 |
| 11. | 65 | 62 | - 3 | 9 |
| 12. | 54 | 50 | - 4 | 16 |
| 13. | 62 | 50 | -12 | 144 |
| 14. | 61 | 65 | 4 | 16 |
| 15. | 60 | 67 | 7 | 49 |
| | 819 | 853 | 34 | 1266 |

| | |
|---|---|
| Mean Score of Initial Test | 54.6 |
| Mean Score of Retest | 56.8 |
| Sum of Difference | 34 |
| Sum of Differences Squared | 1266 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Right Leg Abduction GROUP Experimental

$N = 15$

$D = 34$

$D^2 = 1266$

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{1266 - \frac{1156}{15}}{14}}$$

$$\sqrt{N} \qquad \sqrt{15}$$

$S_{\bar{D}} = .699$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{34}{15} = 2.266$$

$$\text{"t"} = \frac{D}{S_{\bar{D}}} = \frac{2.266}{.699} = \text{"t"} = \underline{3.24}$$

df = N-1 = 14

"t" at .05 level = 2.14

Significant at .05 level

INITIAL TEST AND RETEST OF CONTROL GROUP
IN LEFT LEG ABDUCTION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 56 | 52 | - 4 | 16 |
| 2. | 45 | 46 | 1 | 1 |
| 3. | 51 | 50 | - 1 | 1 |
| 4. | 52 | 55 | 3 | 9 |
| 5. | 45 | 46 | 1 | 1 |
| 6. | 54 | 53 | - 1 | 1 |
| 7. | 60 | 52 | - 8 | 64 |
| 8. | 50 | 52 | 2 | 4 |
| 9. | 60 | 58 | - 2 | 4 |
| 10. | 54 | 42 | -12 | 144 |
| 11. | 63 | 62 | - 1 | 1 |
| 12. | 62 | 61 | - 1 | 1 |
| 13. | 63 | 65 | 2 | 4 |
| | 715 | 694 | -21 | 251 |

| | |
|---|---|
| Mean Score of Initial Test | 54.2 |
| Mean Score of Retest | 53.3 |
| Sum of Differences | -21 |
| Sum of Differences Squared | 251 |

THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS
DERIVED FROM CORRELATED SCORES
FROM SMALL SAMPLES

TEST Left Leg Abduction GROUP Control

N = 13

D = -21

$D^2$ = 251

$S_{\bar{D}}$ = (estimate of the sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} = \sqrt{\frac{251 - \frac{(-21)^2}{13}}{12}}$$

$$\sqrt{N} \qquad \sqrt{13}$$

$S_{\bar{D}}$ = .305

$$\bar{D} = \frac{\Sigma D}{N} = \frac{-21}{13} = 1.615$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{1.615}{.305} = \text{"t"} = \underline{\underline{-5.29}}$$

df = N-1 = 12

"t" at .05 level = 2.18

Significant at .05 level significant decrease

INITIAL TEST AND RETEST OF EXPERIMENTAL GROUP IN LEFT LEG ABDUCTION

| | Initial Test | Retest | Sum of Differences | Differences Squared |
|---|---|---|---|---|
| 1. | 53 | 56 | 3 | 9 |
| 2. | 63 | 65 | 2 | 4 |
| 3. | 62 | 64 | 2 | 4 |
| 4. | 44 | 46 | 2 | 4 |
| 5. | 45 | 56 | 11 | 121 |
| 6. | 54 | 56 | 2 | 4 |
| 7. | 52 | 62 | 10 | 100 |
| 8. | 44 | 52 | 8 | 64 |
| 9. | 47 | 50 | 3 | 9 |
| 10. | 33 | 52 | 19 | 361 |
| 11. | 66 | 68 | 2 | 4 |
| 12. | 56 | 51 | - 5 | 25 |
| 13. | 55 | 48 | - 7 | 49 |
| 14. | 64 | 65 | 1 | 1 |
| 15. | 50 | 62 | 12 | 144 |
| | 788 | 853 | 65 | 755 |

| | |
|---|---|
| Mean Score of Initial Test | 52.5 |
| Mean Score of Retest | 56.8 |
| Sum of Differences | 65 |
| Sum of Differences Squared | 755 |

# THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS DERIVED FROM CORRELATED SCORES FROM SMALL SAMPLES

TEST Left Leg Abduction GROUP Experimental

$N = 15$

$D = 65$

$D^2 = 755$

$S_{\bar{D}}$ = (estimate of sampling error of mean difference ($\bar{D}$)

$$\frac{S_D}{\sqrt{N}} = \sqrt{\frac{D^2 - \frac{(D)^2}{N}}{N-1}} \qquad \frac{\sqrt{755 - \frac{(65)^2}{15}}}{\sqrt{14}}$$

$$\sqrt{N} \qquad \sqrt{15}$$

$S_{\bar{D}} = 1.049$

$$\bar{D} = \frac{\Sigma D}{N} = \frac{65}{15} = 4.333$$

$$\text{"t"} = \frac{\bar{D}}{S_{\bar{D}}} = \frac{4.333}{1.049} = \text{"t"} = \underline{4.13}$$

df = N-1 = 14

"t" at .05 level = 2.14

Significant at .05 level

# APPENDIX C

## FORMULAE APPLIED IN DETERMINING THE STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

$S(\bar{X}_1 - \bar{X}_2) \cdot x =$ (standard error of the difference between means)

$$S(X_1 - X_2) \cdot x = \sqrt{\left(\frac{\Sigma Y \cdot x^2}{N_1 + N_2 - 3}\right)\left(\frac{1}{N} + \frac{1}{N_2}\right)}$$

$$\Sigma Y \cdot x^2 = (\Sigma Y_1^2 + \Sigma Y_2^2) - \frac{(\Sigma X Y)^2}{X^2}$$

$$\Sigma Y_1^2 = \Sigma Y_1^2 - \frac{(\Sigma Y_1)^2}{N_1}$$

$$\Sigma Y_2^2 = \Sigma Y_2^2 - \frac{(\Sigma Y_2)^2}{N_2}$$

$$\Sigma XY = (\Sigma X_1 Y_1 + \Sigma X_2 Y_2) - \frac{(\Sigma X_1 + \Sigma X_2)(\Sigma Y_1 + \Sigma Y_2)}{N_1 + N_2}$$

$$\Sigma X^2 = (\Sigma X_2^2 + \Sigma X_1^2) - \frac{(\Sigma X_1 + \Sigma X_2)^2}{N_1 + N_2}$$

$$\text{"t"} = \frac{\bar{Y}_1 - \bar{Y}_2}{S(\bar{Y}_1 - \bar{Y}_2) \cdot x}$$

STANDARD ERROR OF THE DIFFERENCE
FOR EQUATED GROUPS

TEST Trunk and Hip Flexion GROUP Control

| | Initial Test $X_1$ | Retest $Y_1$ | $X_1^2$ | $Y_1^2$ | $X_1 Y_1$ |
|---|---|---|---|---|---|
| 1. | 146 | 141 | 21,316 | 19,881 | 20,586 |
| 2. | 129 | 128 | 16,641 | 16,384 | 16,512 |
| 3. | 153 | 133 | 23,409 | 17,689 | 20,349 |
| 4. | 168 | 165 | 28,224 | 27,225 | 27,720 |
| 5. | 135 | 138 | 18,225 | 19,044 | 18,630 |
| 6. | 150 | 156 | 22,500 | 24,336 | 23,400 |
| 7. | 130 | 123 | 16,900 | 15,129 | 15,990 |
| 8. | 140 | 138 | 19,600 | 19,044 | 19,320 |
| 9. | 142 | 144 | 20,164 | 20,736 | 20,448 |
| 10. | 178 | 195 | 31,684 | 38,025 | 34,710 |
| 11. | 136 | 135 | 18,496 | 18,225 | 18,360 |
| 12. | 155 | 158 | 24,025 | 24,964 | 24,490 |
| 13. | 130 | 130 | 16,900 | 16,900 | 16,900 |
| | 1,892 | 1,884 | 278,084 | 277,582 | 277,415 |

mean score ($\bar{Y}_1$) of $Y_1$ = 144.9

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Trunk and Hip Flexion GROUP Experimental

| | Initial Test $X_2$ | Retest $Y_2$ | $X_2^2$ | $Y_2^2$ | $X_2 Y_2$ |
|---|---|---|---|---|---|
| 1. | 154 | 149 | 23,716 | 22,201 | 22,946 |
| 2. | 160 | 165 | 25,600 | 27,225 | 26,400 |
| 3. | 153 | 150 | 23,409 | 22,500 | 22,950 |
| 4. | 135 | 133 | 18,225 | 17,689 | 17,955 |
| 5. | 134 | 136 | 17,956 | 18,496 | 18,224 |
| 6. | 155 | 150 | 24,025 | 22,500 | 23,250 |
| 7. | 146 | 148 | 21,316 | 21,904 | 21,608 |
| 8. | 134 | 156 | 17,956 | 24,336 | 20,904 |
| 9. | 137 | 139 | 18,769 | 19,321 | 19,043 |
| 10. | 150 | 135 | 22,500 | 18,225 | 20,250 |
| 11. | 155 | 156 | 24,025 | 24,336 | 24,180 |
| 12. | 158 | 165 | 24,964 | 27,225 | 26,070 |
| 13. | 131 | 146 | 17,161 | 21,316 | 19,126 |
| 14. | 156 | 150 | 24,336 | 22,500 | 23,400 |
| 15. | 135 | 154 | 18,225 | 23,716 | 20,790 |
| | 2,193 | 2,232 | 322,183 | 333,490 | 327,096 |

mean score ($\bar{Y}_2$) of $Y_2$ = 148.8

| | | | | |
|---|---|---|---|---|
| $\leq$4,085 | $\leq$4,116 | $\leq$600,267 | $\leq$611,072 | $\leq$604,511 |

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Trunk and Hip Flexion

$$\Sigma Y_1^2 = 277,582 - \frac{(1884)^2}{13}$$

$$\Sigma Y_1^2 = 4,547$$

$$\Sigma Y_2^2 = 333,490 - \frac{(2232)^2}{15}$$

$$\Sigma Y_2^2 = 1,368.4$$

$$\Sigma XY = 604,511 - \frac{(4085)(4116)}{28}$$

$$\Sigma XY = 4016$$

$$\Sigma X^2 = 600,267 - \frac{(4085)^2}{28}$$

$$\Sigma X^2 = 4,294$$

$$\Sigma Y \cdot x^2 = (4547 + 1,368.4) - \frac{(4016)^2}{4,294}$$

$$\Sigma Y \cdot x^2 = 2,159.4$$

$$S(Y_1 - Y_2) \cdot x = \sqrt{\left(\frac{2159.4}{25}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S(Y_1 + Y_2) \cdot x = 3.526$$

$$\text{"t"} = \frac{144.9 - 148.8}{3.526}$$

$$\text{"t"} = \frac{3.900}{3.526} = \underline{\underline{1.11}}$$

$$df = N_1 + N_2 - 3 = 25$$

"t" at .05 level = 2.06

not significant

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Trunk and Hip Extension GROUP Control

| | Initial Test $X_1$ | Retest $Y_1$ | $X_1^2$ | $Y_1^2$ | $X_1 Y_1$ |
|---|---|---|---|---|---|
| 1. | 43 | 60 | 1,849 | 3,600 | 2,580 |
| 2. | 44 | 42 | 1,936 | 1,764 | 1,848 |
| 3. | 45 | 62 | 2,025 | 3,844 | 2,790 |
| 4. | 74 | 71 | 5,476 | 5,041 | 5,254 |
| 5. | 63 | 61 | 3,969 | 3,721 | 3,843 |
| 6. | 45 | 48 | 2,025 | 2,304 | 2,160 |
| 7. | 40 | 42 | 1,600 | 1,764 | 1,680 |
| 8. | 30 | 33 | 900 | 1,089 | 990 |
| 9. | 43 | 42 | 1,849 | 1,764 | 1,806 |
| 10. | 55 | 58 | 3,025 | 3,364 | 3,190 |
| 11. | 50 | 51 | 2,500 | 2,601 | 2,550 |
| 12. | 59 | 60 | 3,481 | 3,600 | 3,540 |
| 13. | 53 | 55 | 2,809 | 3,025 | 2,915 |
| | 644 | 685 | 33,444 | 37,481 | 35,146 |

mean score ($\overline{Y}_1$) of $Y_1$ = 52.6

STANDARD ERROR OF THE DIFFERENCE
FOR EQUATED GROUPS

TEST Trunk and Hip Extension GROUP Experimental

| | Initial Test $X_2$ | Retest $Y_2$ | $X_2^2$ | $Y_2^2$ | $X_2 Y_2$ |
|---|---|---|---|---|---|
| 1. | 45 | 61 | 2,025 | 3,721 | 2,745 |
| 2. | 39 | 57 | 1,521 | 3,249 | 2,223 |
| 3. | 42 | 56 | 1,764 | 3,136 | 2,352 |
| 4. | 30 | 40 | 900 | 1,600 | 1,200 |
| 5. | 35 | 45 | 1,225 | 2,025 | 1,575 |
| 6. | 43 | 46 | 1,849 | 2,116 | 1,978 |
| 7. | 51 | 50 | 2,601 | 2,500 | 2,550 |
| 8. | 33 | 34 | 1,089 | 1,156 | 1,122 |
| 9. | 38 | 56 | 1,444 | 3,136 | 2,128 |
| 10. | 32 | 44 | 1,024 | 1,936 | 1,408 |
| 11. | 55 | 63 | 3,025 | 3,969 | 3,465 |
| 12. | 56 | 69 | 3,136 | 4,761 | 3,864 |
| 13. | 33 | 34 | 1,089 | 1,156 | 1,122 |
| 14. | 46 | 49 | 2,116 | 2,401 | 2,254 |
| 15. | 50 | 55 | 2,500 | 3,025 | 2,750 |
| | 628 | 759 | 27,308 | 39,887 | 32,736 |

mean score ($\bar{Y}_2$) of $Y_2$ = 52.6

| | | | | |
|---|---|---|---|---|
| $\Sigma$1,272 | $\Sigma$1,444 | $\Sigma$60,752 | $\Sigma$77,368 | $\Sigma$67,882 |

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Trunk and Hip Extension

$$\Sigma Y_1^2 = 37,481 - \frac{(685)^2}{13} \qquad \Sigma Y_1^2 = 1386$$

$$\Sigma Y_2^2 = 39,887 - \frac{(759)^2}{15} \qquad \Sigma Y_2^2 = 1481$$

$$\Sigma XY = 67,882 - \frac{(1272)\ (1444)}{28} \qquad \Sigma XY = 2283$$

$$\Sigma X^2 = 60,752 - \frac{(1272)^2}{28} \qquad \Sigma X^2 = 2966$$

$$\Sigma Y \cdot x^2 = (1386 + 1481) - \frac{(2283)^2}{2966}$$

$$\Sigma Y \cdot x^2 = 1109$$

$$S\ (Y_1 - Y_2) \cdot x = \sqrt{\left(\frac{1109}{25}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S\ (\bar{Y}_1 - \bar{Y}_2) \cdot x = 2.528$$

$$\text{"t"} = \frac{52.6 - 50.6}{2.528} = \frac{2.000}{2.528} \qquad \text{"t"} = \underline{.791}$$

$$df = N_1 + N_2 - 3 = 25$$

"t" at .05 level = 2.06

not significant

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Stork Stand GROUP Control

| | Initial Test $X_1$ | Retest $Y_1$ | $X_1^2$ | $Y_1^2$ | $X_1 Y_1$ |
|---|---|---|---|---|---|
| 1. | 10 | 5 | 100 | 25 | 50 |
| 2. | 10 | 2 | 100 | 4 | 20 |
| 3. | 10 | 10 | 100 | 100 | 100 |
| 4. | 5 | 4 | 25 | 16 | 20 |
| 5. | 8 | 4 | 64 | 16 | 32 |
| 6. | 10 | 10 | 100 | 100 | 100 |
| 7. | 1 | 10 | 1 | 100 | 10 |
| 8. | 10 | 10 | 100 | 100 | 100 |
| 9. | 3 | 2 | 9 | 4 | 6 |
| 10. | 8 | 10 | 64 | 100 | 80 |
| 11. | 8 | 9 | 64 | 81 | 72 |
| 12. | 9 | 8 | 81 | 64 | 72 |
| 13 | 9 | 8 | 81 | 64 | 72 |
| | 101 | 92 | 889 | 774 | 734 |

mean score ($\bar{Y}_1$) of $Y_1 = 7.0$

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Stork Stand GROUP Experimental

| | Initial Test $X_2$ | Retest $Y_2$ | $X_2^2$ | $Y_2^2$ | $X_2 Y_2$ |
|---|---|---|---|---|---|
| 1. | 10 | 10 | 100 | 100 | 100 |
| 2. | 9 | 3 | 81 | 9 | 27 |
| 3. | 4 | 3 | 16 | 9 | 12 |
| 4. | 5 | 7 | 25 | 49 | 35 |
| 5. | 5 | 10 | 25 | 100 | 50 |
| 6. | 1 | 10 | 1 | 100 | 10 |
| 7. | 10 | 10 | 100 | 100 | 100 |
| 8. | 4 | 4 | 16 | 16 | 16 |
| 9. | 10 | 10 | 100 | 100 | 100 |
| 10. | 10 | 5 | 100 | 25 | 50 |
| 11. | 5 | 10 | 25 | 100 | 50 |
| 12. | 8 | 10 | 64 | 100 | 80 |
| 13. | 4 | 9 | 16 | 81 | 36 |
| 14. | 6 | 9 | 36 | 81 | 54 |
| 15. | 10 | 10 | 100 | 100 | 100 |
| | 101 | 120 | 805 | 1,070 | 820 |

mean score ($\bar{Y}_2$) of $Y_2$ = 8.0

| | | | | |
|---|---|---|---|---|
| £202 | £212 | £1,694 | £1,844 | £1,554 |

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Stork Stand

$$\Sigma Y_1^2 = 774 - \frac{(92)^2}{13} \qquad \Sigma Y_1^2 = 123$$

$$\Sigma Y_2^2 = 1070 - \frac{(120)^2}{15} \qquad \Sigma Y_2^2 = 110$$

$$\Sigma XY = 1554 - \frac{(202)\,(212)}{28} \qquad \Sigma XY = 25$$

$$\Sigma X^2 = 1694 - \frac{(202)^2}{28} \qquad \Sigma X^2 = 236$$

$$\Sigma Y \cdot x^2 = 123 + 110 - \frac{(25)^2}{236}$$

$$\Sigma Y \cdot x^2 = 230.35$$

$$S\,(\bar{Y}_1 - \bar{Y}_2) \cdot x = \sqrt{\left(\frac{230.35}{25}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S\,(\bar{Y}_1 - \bar{Y}_2) \cdot x = 1.15$$

$$\text{"t"} = \frac{8.0 - 7.0}{1.15} \qquad \text{"t"} = \underline{\underline{.870}}$$

$df = N_1 + N_2 - 3 = 25$

"t" at .05 level = 2.06

not significant

STANDARD ERROR OF THE DIFFERENCE
FOR EQUATED GROUPS

TEST Right Leg Abduction GROUP Control

| | Initial Test $X_1$ | Retest $Y_1$ | $X_1^2$ | $Y_1^2$ | $X_1 Y_1$ |
|---|---|---|---|---|---|
| 1. | 50 | 57 | 2,500 | 3,249 | 2,850 |
| 2. | 45 | 46 | 2,025 | 2,116 | 2,070 |
| 3. | 46 | 59 | 2,116 | 3,481 | 2,714 |
| 4. | 59 | 59 | 3,481 | 3,481 | 3,481 |
| 5. | 50 | 50 | 2,500 | 2,500 | 2,500 |
| 6. | 44 | 52 | 1,936 | 2,704 | 2,288 |
| 7. | 50 | 48 | 2,500 | 2,304 | 2,400 |
| 8. | 46 | 45 | 2,116 | 2,025 | 2,070 |
| 9. | 57 | 58 | 3,249 | 3,364 | 3,306 |
| 10. | 45 | 45 | 2,025 | 2,025 | 2,025 |
| 11. | 66 | 67 | 4,356 | 4,489 | 4,422 |
| 12. | 68 | 68 | 4,624 | 4,624 | 4,624 |
| 13. | 66 | 64 | 4,356 | 4,096 | 4,224 |
| | 705 | 718 | 37,784 | 40,458 | 38,974 |

mean score ($\bar{Y}_1$) of $Y_1$ = 55.2

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Right Leg Abduction GROUP Experimental

| | Initial Test $X_2$ | Retest $Y_2$ | $X_2^2$ | $Y_2^2$ | $X_2 Y_2$ |
|---|---|---|---|---|---|
| 1. | 52 | 56 | 2,704 | 3,136 | 2,912 |
| 2. | 55 | 66 | 3,025 | 4,356 | 3,630 |
| 3. | 75 | 69 | 5,625 | 4,761 | 5,175 |
| 4. | 41 | 43 | 1,681 | 1,849 | 1,763 |
| 5. | 43 | 68 | 1,849 | 4,624 | 2,924 |
| 6. | 57 | 50 | 3,249 | 2,500 | 2,850 |
| 7. | 54 | 48 | 2,916 | 2,304 | 2,592 |
| 8. | 47 | 50 | 2,209 | 2,500 | 2,350 |
| 9. | 49 | 55 | 2,401 | 3,025 | 2,695 |
| 10. | 44 | 54 | 1,936 | 2,916 | 2,376 |
| 11. | 65 | 62 | 4,225 | 3,844 | 4,030 |
| 12. | 54 | 50 | 2,916 | 2,500 | 2,700 |
| 13. | 62 | 50 | 3,844 | 2,500 | 3,100 |
| 14. | 61 | 65 | 3,721 | 4,225 | 3,965 |
| 15. | 60 | 67 | 3,600 | 4,489 | 4,020 |
| | 819 | 853 | 45,901 | 49,529 | 47,082 |

mean score ($\bar{Y}_2$) of $Y_2$ = 56.8

| | | | | |
|---|---|---|---|---|
| ≤1,524 | ≤1,571 | ≤83,685 | ≤89,987 | ≤86,056 |

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Right Leg Abduction

$$\Sigma Y_1^2 = 40,458 - \frac{(718)^2}{13} \qquad \Sigma Y_1^2 = 802$$

$$\Sigma Y_2^2 = 49,529 - \frac{(853)^2}{15} \qquad \Sigma Y_2^2 = 1021$$

$$\Sigma XY = 86,056 - \frac{(1524)(1571)}{28} \qquad \Sigma XY = 548$$

$$\Sigma X^2 = 83,685 - \frac{(1524)^2}{28} \qquad \Sigma X^2 = 736$$

$$\Sigma Y \cdot x^2 = (802 + 1021) - \frac{(548)^2}{736}$$

$$\Sigma Y \cdot x^2 = 1415$$

$$S\,(\bar{Y}_1 - \bar{Y}_2) \cdot x = \sqrt{\left(\frac{1415}{25}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S\,(\bar{Y}_1 - \bar{Y}_2) \cdot x = 2.855$$

$$\text{"t"} = \frac{55.2 - 56.8}{2.855} \qquad \text{"t"} = \underline{\underline{.560}}$$

$df = N_1 + N_2 - 3 = 25$

"t" at .05 level = 2.06

not significant

STANDARD ERROR OF THE DIFFERENCE
FOR EQUATED GROUPS

TEST Left Leg Abduction GROUP Control

| | Initial Test $X_1$ | Retest $Y_1$ | $X_1^2$ | $Y_1^2$ | $X_1 Y_1$ |
|---|---|---|---|---|---|
| 1. | 56 | 52 | 3,136 | 2,704 | 2,912 |
| 2. | 45 | 46 | 2,025 | 2,116 | 2,070 |
| 3. | 51 | 50 | 2,601 | 2,500 | 2,550 |
| 4. | 52 | 55 | 2,704 | 3,025 | 2,860 |
| 5. | 45 | 46 | 2,025 | 2,116 | 2,070 |
| 6. | 54 | 53 | 2,916 | 2,809 | 2,862 |
| 7. | 60 | 52 | 3,600 | 2,704 | 3,120 |
| 8. | 50 | 52 | 2,500 | 2,704 | 2,600 |
| 9. | 60 | 58 | 3,600 | 3,364 | 3,480 |
| 10. | 54 | 42 | 2,916 | 1,764 | 2,268 |
| 11. | 63 | 62 | 3,969 | 3,844 | 3,906 |
| 12. | 62 | 61 | 3,844 | 3,721 | 3,782 |
| 13. | 63 | 65 | 3,969 | 4,225 | 4,095 |
| | 715 | 694 | 39,805 | 37,596 | 38,575 |

mean score ($\bar{Y}_1$) of $Y_1$ = 53.3

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Left Leg Abduction GROUP Experimental

| | Initial Test $X_2$ | Retest $Y_2$ | $X_2^2$ | $Y_2^2$ | $X_2 Y_2$ |
|---|---|---|---|---|---|
| 1. | 53 | 56 | 2,809 | 3,136 | 2,968 |
| 2. | 63 | 65 | 3,969 | 4,225 | 4,095 |
| 3. | 62 | 64 | 3,844 | 4,096 | 3,968 |
| 4. | 44 | 46 | 1,936 | 2,116 | 2,024 |
| 5. | 45 | 56 | 2,025 | 3,136 | 2,520 |
| 6. | 54 | 56 | 2,916 | 3,136 | 3,024 |
| 7. | 52 | 62 | 2,704 | 3,844 | 3,224 |
| 8. | 44 | 52 | 1,936 | 2,704 | 2,288 |
| 9. | 47 | 50 | 2,209 | 2,500 | 2,350 |
| 10. | 33 | 52 | 1,089 | 2,704 | 1,716 |
| 11. | 66 | 68 | 4,356 | 4,624 | 4,488 |
| 12. | 56 | 51 | 3,136 | 2,601 | 2,856 |
| 13. | 55 | 48 | 3,025 | 2,304 | 2,640 |
| 14. | 64 | 65 | 4,096 | 4,225 | 4,160 |
| 15. | 50 | 62 | 2,500 | 3,844 | 3,100 |
| | 788 | 853 | 42,550 | 49,195 | 45,421 |

mean score ($\bar{Y}_2$) of $Y_2$ = 56.9

| | | | | |
|---|---|---|---|---|
| £1,503 | £1,547 | £82,355 | £86,791 | £83,996 |

## STANDARD ERROR OF THE DIFFERENCE FOR EQUATED GROUPS

TEST Left Leg Abduction

$$\Sigma Y_1^2 = 37,596 - \frac{(694)^2}{13} \qquad \Sigma Y_1^2 = 547$$

$$\Sigma Y_2^2 = 49,195 - \frac{(853)^2}{15} \qquad \Sigma Y_2^2 = 687$$

$$\Sigma XY = 83,996 - \frac{(1503)\,(1547)}{28} \qquad \Sigma XY = 955$$

$$\Sigma X^2 = 82,355 - \frac{(1503)^2}{28} \qquad \Sigma X^2 = 1676$$

$$\Sigma Y \cdot x^2 = (547 + 687) - \frac{(955)^2}{1676}$$

$$\Sigma Y \cdot x^2 = 689$$

$$S(\bar{Y}_1 - \bar{Y}_2) \cdot x = \sqrt{\left(\frac{689}{25}\right)\left(\frac{1}{15} + \frac{1}{13}\right)}$$

$$S(\bar{Y}_1 - \bar{Y}_2) \cdot x = 1.992$$

$$\text{"t"} = \frac{53.3 - 56.9}{1.992} \qquad \text{"t"} = \underline{\underline{1.81}}$$

$df = N_1 + N_2 - 3 = 25$

"t" at .05 level = 2.06

not significant

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