DYNAMIC BALANCE AND ANKLE PLANTAR FLEXION AND DORSAL FLEXION STRENGTH IN SECOND GRADE BOYS

By

WILLIAM LYLE CARLETON

Bachelor of Science
Phillips University
Enid, Oklahoma
1965

Master of Science in Physical Education
Indiana University
Bloomington, Indiana
1973

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF EDUCATION
July, 1980

Thesis
1980D
C285d
cop. 2

OKLAHOMA STATE UNIVERSITY LIBRARY

DYNAMIC BALANCE AND ANKLE PLANTAR FLEXION AND

DORSAL FLEXION STRENGTH IN SECOND

GRADE BOYS

Thesis Approved:

Thesis Adviser

Dean of the Graduate College

1069465

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to the members of my committee: Dr. Betty Abercrombie, Dr. John Bayless, Dr. A. B. Harrison, Dr. Thomas Karman and Dr. O. D. Wikoff. Special thanks to Dr. Wikoff for his expertise and knowledge in directing this study and to Dr. "A" and Dr. "B" for their many years of concern for my growth as a professional educator.

I would also like to recognize the following individuals for their help in this study:

Dennis Cyr and his second grade physical education classes.

Dr. Betty Edgley, Mrs. Jane Mitchell, Mr. Allen Peterson, Ms. Cheryl Mangum and Mr. John Allcott for assisting in the collection of data.

Dr. Bill Warde for his indispensible help with the computer program and data analysis.

Mr. Larry Bilhartz for his time and effort as the photographer.

Dr. M. A. Thompson for her help in preparing this study.

My parents, Bert and Lyle Carleton and my in-laws, Bob and Wilma Pennington for their love and concern.

Finally, my friend, lover and wife, Nancy Jo Pennington-Carleton, who makes everything worthwhile.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

There has been an unparalleled concern accorded to the learning of motor skills for young children in the last fifteen years (1). This interest has resulted in many new and stimulating changes in content and teaching styles for the physical education program in the elementary schools. A consequence of this period of change has been the development of perceptual-motor programs which employ balance as an important ingredient of motor development.

Good traits of balance in young children are of importance for the attainment of basic motor skills. Drowatzky (2) revealed that balance is essential to the development of motor performance. The child, through the development of balance, will learn to associate with the pull of gravity and begin to compose a reference system for movement. Gallahue (3) and Gallahue, Werner, and Luedke (4) described balance as the most basic facet of learning to move.

The child who lacks the capacity for balance finds locomotor and manipulative skills almost unattainable. The ability to balance the body is vital to the readiness of higher perceptual-motor skills, such as throwing with accuracy and form or running a demanding obstacle course (5). Without an integrated balance program during rudimentary learning, further learning of more highly skilled motor patterns will be difficult. The fact that balance is a very important component of efficient movement makes it one foundation for proficient motor learning (6) (7) (8) (9).

Perceptual-motor programs have traditionally emphasized the need for a wide variety of activities to enhance motor skills within the perceptual-motor realm. The learning of the specific skill of balancing has also been treated under this umbrella which employs a wide variety of balancing activities. Drowatzky (10) stated that there is no prevalent program to enhance balance, and that the curriculum for the young child should include a diversification of learning situations. Gallahue (3) declared that young children should develop balance skills at an early age indirectly through the repetition of activities specifically designed for the enhancement of equilibrium. In general, these learning activities involve locomotor, nonlocomotor, manipulative, and balancing skills. Young children who have not had the opportunity for a broad scope of activities will run the chance of having their ability to achieve balance impeded (11). To emphasize the need of learning at an early age, Robert Singer (12) wrote:

> The extent to which a child successfully experiences perceptual-motor behaviors and develops motorically will probably influence his rate of achievement when confronted with so-called new tasks. However, it might be theoretically argued, and it has been, that very few activities are really new to the learner following the childhood years (p. 38).

It is the child who runs in a game, climbs a tree, bounces on a pogo stick, rides a skatebroad, does a cartwheel and walks a railroad track that will have a better chance for good balance and coordination.

Good balance and strength are vital to the proper learning of motor skills, and both play a significant role in movement activities. All voluntary movements of the body require skeletal muscle operation to perform perceptual-motor skills like running, skipping and balancing (13). Balance is controlled by the vestibular system, vision and the muscular system. These different body functions have to be working together for balance to be useful in the daily life of the child.

A certain degree of muscle tension and sensory perception are needed to maintain the body in a state of equilibrium (14). Balance can be lost through the lack of muscle tension and through an improper amount of muscular strength required to maintain a balance position. Cratty (6) reported that the visual and muscular system working together are the primary sources of balance, and to these factors Stallings (15) included the possibility of trunk and leg strength. Both muscular strength and balance are included in Arnheim and Sinclair's (16) components of motor fitness, as well as in Arnett and Thompson's (17) elements of perceptual-motor and motor performance. Muscular compensations will, in effect, keep the child in proper balance with additional information from the intricate physiological and sensory mechanisms of the body.

It is extensively acknowledged that musuclar strength is an essential element in performing motor skills; however, the function of strength in support of dynamic balance in children is relatively unknown. A small number of researchers have studied components of dynamic balance and strength in the same study, but the populations investigated have been college age or above. There is a vital need for more research in this area with young children as the subjects. The few studies that have involved measures of balance with ankle plantar flexion and ankle dorsal flexion as measures of muscular strength have utilized an older population of subjects. There are many questions that have not been researched involving the young child; moreover, with the expansion and growth in the knowledge of the importance of physical education for the young, there is a need for this research so that learning and teaching will meet the demands of our fast changing society.

Statement of the Problem

The primary purpose of this study was to determine the relationship of dynamic balance ability to measured strengths of ankle dorsal flexion and ankle plantar flexion in second grade boys.

A secondary purpose was to determine if a significant difference existed between performance scores of the following two groups:

1) subjects who took part in their regular physical education class and did strengthening exercises for the ankle before each class;

2) subjects who took part in their regular physical education class without specific ankle-strengthening exercises.

Significance of the Study

Physical educators have been using a wide range of activities as the teaching medium for enhancing balancing skills. Muscular strength is needed to maintain balance which is essential to the development of motor performance. It, therefore, appears to this writer that increasing ankle plantar and dorsal flexion strength should be another way of improving balance. Exercises to improve these ankle strengths will be another teaching medium to add to a wide variety of activities.

Hypotheses

1) There is no significant relationship between dynamic balance and ankle plantar flexion strength.

2) There is no significant relationship between dynamic balance and ankle dorsal flexion strength.

3) There is no significant difference between the control group and experimental group after the treatment period in measures of balance, dorsal flexion strength and plantar flexion strength.

Delimitations

The subjects of this study were limited to second grade boys at Westwood Elementary School in Stillwater, Oklahoma, who attend regular physical education classes.

Limitations of Study

1) There was no control of activities outside of the physical education class for the subjects.

2) Anxiety of the subjects was expected, even though the subjects were orientated to the different testing equipment and testers.

Assumptions

1) The stabilometer was a valid test of dynamic balance.

2) Cable-tension strength tests were valid tests of dorsal flexion strength and plantar flexion strength.

3) The subjects gave their best efforts on each test of strength and balance.

4) All subjects were in good health and capable of participating in physical activity.

Definition of Terms

Dorsal flexion - Lifting the foot from the anatomical position in the direction of the front surface of the leg (18).

Dynamic balance - The ability to maintain body control while moving (12).

Motor development - Learning to move with efficiency from simple to increasingly more complex skills (12.)

Motor learning - The procurement of skills which involves the body moving in a coordinated manner (19).

Motor skill - The muscular action that is necessary for the efficient performance of a desirable act (12).

Muscular strength - The greatest possible force which can be employed in a solitary muscular contraction (19).

Perceptual-motor - "The capability of an individual to process, interpret, and use sensory stimuli for performing some type of task" (20, p. 21).

Plantar flexion - From the anatomical position, decreasing the height of the foot so as to align the foot's long axis with that of the leg (18).

Stabilometer - An apparatus which measures dynamic balance and requires the subject to maintain balance on an unstable board (12).

CHAPTER II

REVIEW OF SELECTED LITERATURE

The review of literature will be divided into four different sections: (1) strength tests; (2) dynamic balance tests; (3) balance and ankle strength; and (4) summary.

Strength Tests

The history of physical education in the United States has shown an interest in tests of strength that indicated the physical abilities of students. The true source of the evolution of analyzing strength has been lost since ancient times. Artistic paintings dating back to c.2500 B.C. depict strength exercises on the walls of Egyptian tombs. French anthropologists were credited with the first recorded measures of strength. In 1702 the first study using man as subjects was developed (21).

Hunsicker and Donnelly (22) reported that an Englishman named Graham was the first researcher to use a dynamometer. The first practical dynamometer was developed in 1807 by Regnier, a Frenchman. This instrument was an eliptical spring dynamometer which was used to measure grip, arm and back muscle strength. The dynamometer had some small changes over the years, and in 1875 Galton designed a model which used a clock-like apparatus to indicate arm strength test results.

The first dynamometer used in the United States was used by Sargent at Harvard in 1880. In the late 1890's, Smedley advanced the dynamometer with the advent of an adjustable hand grip. This new instrument made strength studies of children possible and practical. A Harvard physiologist, Martin, tested polio victims in 1914 with a different type of dynamometer which employed a spring scale. This new instrument measured the force needed to overpower a maximal opposition instead of the force of one muscular contraction (22).

The use of these different types of dynamometers was explained by Hunsicker and Donnelly when they wrote (22):

> Many various kinds of spring steel dynamometers have been developed since Regnier first introduced his crude device in 1807. Although slightly different in design, all of the spring steel dynamometers are based upon the same principle, namely deformation of a piece of steel either in the form of a ring, ellipse, or coil with the deformation of the metal being proportional to the force applied. In the United States, physical educators have generally used the same spring steel dynamometers developed by Sargent, psychologists the Smedley dynamometer, and orthopedists and physical therapists Martin's spring balance apparatus or its improved counterpart (p. 418).

In 1954, Clarke (23) used college males to compare muscle strength scores using the cable tensiometer method, Wakim-Porter strain gauge, spring gauge and the Newman myometer. The tensiometer was developed after World War II and was originally used in testing aircraft control cables. The Wakim-Porter strain gauge was used in a Mayo Clinic study, the spring scale by Martin and the Newman myometer was used in studies by Newman who gave the instrument his name. The study reported the following conclusions:

1) The cable tensiometer had the best precision for testing strength and was considered the most useful of the testing equipment.

2) The strain gauge had satisfactory results but was very sensitive to changes in temperature and tests that involved a high amount of strength.

3) The spring scale was also satisfactory but could only be used in tests of 100 pounds or below. Another problem was the movement of the testing apparatus when tension was applied.

4) The myometer was limited to tests below 60 pounds and yielded objectivity coefficients below .82.

5) Objectivity coefficients ranging from .90 to .96 were reported for the tensiometer.

This investigation by Clarke has proven the cable tensiometer method reliable and valid. Numerous studies of muscular strength have used this method in their research, and the instrument has become a standard research tool (24) (25) (26) (27) (28) (29) (30).

A study by Rogers (31) in 1925 disclosed the relationship of muscular strength and motor performance. His subjects were college students who were tested for strength, physical condition and motor performance. The results of this study provided an upsurge for research in the physical education area dealing with these variables (21). Grip strength and specific handball skills have shown a high degree of correlation. Total grip strength, non-preferred grip strength and preferred grip strength were shown to have a high degree of relationship to a 30-second wall volley test (32). Clarke and Degutis (33) found a high correlation between some strength variables and standing broad jump scores of twelve year old boys. While some scores showed a low relationship, there was a high correlation between total body strength index, hip extension strength, knee extension strength, ankle plantar flexion strength and elbow flexion strength.

Whitley and Smith (34) used four different groups to study the effect of improving strength on the speed of an arm movement. There was a significant improvement in both strength and in speed of arm movement for both the isometric and isotonic training groups. The arm movement training group and the control group showed no significant improvement for strength or speed of the arm movement.

Carpenter (35) correlated two dynamic strength measures with a composite score of the motor performance of primary school children. The results indicated a high relationship between strength and performance scores on the shotput and broad jump events. Espenschade and Eckert (36) reported on a study searching the relationship between strength of the leg extensor muscles and standing broad jump scores. The correlation was significant for the one hundred elementary school girls that were tested.

Dynamic Balance Tests

Tests of dynamic balance require the individual to maintain equilibrium while in some type of motion (15). Singer (12) indicated the following three general apparatus have been used for measuring dynamic balance:

1) A narrow surface apparatus which the subject tries to walk without falling off.

2) A free-standing ladder upon which the subject climbs as high as possible before it falls over.

3) An unstable platform upon which the subject must try to maintain equilibrium.

A 1932 study by Alden, Horton and Caldwell (37) used a balance beam to measure the dynamic balance ability of college women. The results of this study revealed low reliability coefficients. The Springfield Beam-Walking Test was developed in 1947 to measure dynamic balance in children and adults. This test consisted of nine beams of equal height and length but different in width. The width varied from four inches to .25 of an inch. The subjects were to take ten steps on each beam starting with the widest beam and progressing to the narrowest beam. Reliability scores have been high with children and satisfactory with adults (38). Walking the balance beam is part of the Purdue Perceptual-Motor Survey, which is used for testing possible non-achievers. The subjects of this survey were instructed to walk the beam forward, backward and sideways using the tester's subjective evaluation as the criterion score (39). Di Nucci (40) in a 1975 study used scores from a forward railwalk as one factor in determining motor performance. Boys ages six to nine were used as subjects in comparing the difference between black and Caucasian children in the performance of dynamic balance. Several other studies (41) (42) (43) have also utilized a balance beam or a rail type apparatus in measuring dynamic balance.

Bachman (44) (45) developed the free-standing ladder as a measure of total body balance. His 1961 publications reported that the criterion score was the number of ladder rungs the subject could climb in a set period of time. Williams and Hearfield (46) utilized the Bachman ladder and his criteria for scoring in a gross body balance study of high school students.

There have been several different designs for stabilometers since 1934 when a prototype apparatus, the wheel balance test, was used to measure dynamic balance (47). The basic stabilometer design has been much like a teeter-totter platform with the center of rotation in the middle. The location of the platform upon which the subject stood and the center of rotation have been the major design differences. A design by Ryan (48) had the platform located 25 cm. above the center of rotation, while another model by Bachman (44) (45) had the platform positioned ten inches below the center of rotation. A third model had the platform located on the rod which is the center of rotation (49). The different types of stabilometers have been proven to be reliable instruments by several investigators (44) (45) (50) (51).

Melnick (52) and Barty and Smith (53) measured dynamic balance with a stabilometer using two timing apparatus. A trial clock was set for a specific time and ran continuously during the trial. This clock automatically stopped and started the score clock. Microswitches located on the base of the stabilometer were connected to the score clock which would run when the ends of the stabilometer platform touched the microswitches. This procedure connected a chronoscope to the microswitches which automatically stopped when the platform touched the microswitches. This device made it possible to measure very brief intervals of time when the platform rested on the microswitches. Roehrig (49) scored balance time only when the platform was in a horizontal position. This design was used to make the balancing task more difficult for the study of certain drug effects. Brodie (54) added an oscillograph which displayed quantitative and qualitative information of the stabilometer performance. "From the oscillographic display it is possible to measure accurately the time spent in balance and also to observe the type of movement pattern between and within individuals (56, p. 851)." The increased use of the stabilometer in laboratories to study the variables affecting motor skill performance and learning has brought about the construction of these differently designed apparatus. Even though the stabilometer has taken different designs, the device is typically constructed with a horizontal platform which pivots on a midpoint axis (55).

Travis (56), as early as 1945, declared that the stabilometer measured dynamic balance. The stabilometer requires the subject to maintain balance on an unstable platform. The movement of this platform is the dynamic action of the balance performance (51). "The stabilometer has received fairly extensive use as an instrument for measuring dynamic balance and for examining various aspects of motor learning (57, p. 619)."

The stabilometer has been used to measure dynamic balance in young normal and atypical children. Stevenson (58) studied the balance variables of third and fifth grade boys and girls. Lindsey and O'Neal (59) investigated dynamic balance of eight-year-old deaf and hearing children. Husak and Magill (60) used the stabilometer to measure dynamic balance, which was one part of a three-part perceptual-motor ability test. Subjects of this study were boys and girls from the first, second and third grades. Horgan (61) studied the stabilometer performance of mentally retarded children with a mean age of 12.6 years. Male and female subjects of this study had IQs ranging from 55 to 80. Eckert and Rarick (62) administered the stabilometer test to both normal and educable mentally retarded (EMR) children. The EMR children ranged from age 6 to 30 and the normal children ranged from 6 to 9 years of age. The results of using young children on the stabilometer have been good, with the safety of the child not endangered.

Balance and Ankle Strength

It is generally acknowledged that muscular strength is an important element in motor skill performance (6) (9) (10) (19) (63) (64). Di Nucci (30), Clarke and Munroe (64) constructed a test battery to assess the motor fitness level of boys in the lower elementary grades. Ankle plantar flexion was one of three strength tests used to arrive at a strength composite, which was used to predict overall body strength. Clarke (65) reported on a study which correlated cable-tension strength tests results with a 60 yard shuttle run. The correlation was significant at the .01 level for these 13-year-old male subjects. Another study reported by Clarke (65) used ankle dorsal flexion strength as one variable in finding the average lower-body strength. Subjects were upper elementary school boys who were participants in athletics and those who were nonparticipants in the athletic program. The athletic group had a significantly stronger lower-body strength than did the nonparticipants.

Jones (66) studied the effects of ankle exercises on the vertical jump performance of 120 boys in grades four through seven. An exercise program to strengthen the ankles did not produce better vertical jump scores but did produce improvements in strength. To help children with movement problems, a program developed by Pyfer (67) had the child wear weighted cuffs on the ankles and wrists. The weighted cuff was used to provide additional clues to the perceptual system so the child could enhance balance and movement. As the child began to move with efficiency, the cuffs were gradually lowered in weight until they could finally be eliminated.

Gross and Thompson (68) investigated the relationship between dynamic balance and the swimming ability of male college students. The results indicated that individuals who had better dynamic balances could swim faster and had a better overall swimming ability. Bushey (69) studied the relationship of modern dance to static balance and strength for college women. There was a significant relationship between modern dance and strength but not modern dance and static balance. Szymanski (70) used the stabilometer to measure the dynamic balance ability of college women athletes with their ankles taped and untaped. The author concluded that ankle-taping had a negative effect on dynamic balance. A study reported by Espenschade and Eckert (36) indicated a high relationship between dynamic balance and ratings of physical ability of junior high school boys. Kennedy (71) researched the effects of weight training and Olympic-style lifting on dynamic balance of 15-year-old boys. A balance beam was used to measure dynamic balance, and the increased amount of weight lifted was used to measure gains in strength. After a six week training period, the subjects did improve in lower body strength, upper body strength, and dynamic balance. The results of the dynamic balance test were approaching the significant level.

It was as early as 1934 when Beebe (72) declared that the muscle action through the ankle joint actively controls balance for the individual. In the literature, only two studies could be found that have specifically correlated balance and ankle strength. In 1969, Wyrick (28) measured ankle strength to find out its relationship to performances of static balance. The subjects were fifty-six college females who were measured for ankle plantar and dorsal flexion strength using a cable tensiometer, as suggested by Clarke (65). Static balance was measured by means of the Bass Stick Test. The results indicated that ankle plantar and dorsal flexion strength were not significantly related to static balance.

Laney (73) reported on the relationship of anthropometric and strength correlates to dynamic balance. The author used the stabilometer to measure dynamic balance and a cable tensiometer to measure strength of college women. Ankle plantar flexion strength was among seventeen anthropometric and strength variables compared to measures of dynamic balance. For this study it was concluded that strength was a relatively unimportant element of dynamic balance.

Summary

From the review of selected literature it has been shown that the cable tensiometer is a valid and reliable instrument for measuring strength. The stabilometer is a proven reliable instrument and has been used by many researchers to study dynamic balance.

There is evidence that muscular strength is important in the performance of motor skills. The exact relationship of muscular strength to motor activity performance has yet to be determined. Studies of this nature have shown contradictory results, indicating also that muscular strength may be a minimal influence in performance.

There is also ample evidence that balance is a very important factor in efficient and meaningful movement. Dynamic balance, which requires the individual to maintain equilibrium while in motion, is one of the most important types of balance skills. The child who has good balance abilities will find it easier to learn more highly skilled motor activities.

The only study located relating ankle strength to dynamic balance was concerned with adult women. No correlation was found and it was suggested that this could have been due to the adults compensating for weak ankles. No study was pursued to determine if strengthening the ankles would further increase balance. If this could be determined then developing ankle strength in the young child could be achieved more quickly than teaching balance itself.

CHAPTER III

METHODS AND PROCEDURES

The primary purpose of this study was to determine the relationship of dynamic balance ability to measured strengths of ankle dorsal flexion and ankle plantar flexion in second grade boys. A secondary purpose was to determine if a significant difference existed between performance scores of two differently treated groups. This chapter will present the methodology and procedures for evaluating dynamic balance, ankle plantar flexion strength and ankle dorsal flexion strength.

Selection of Subjects

The subjects in this investigation were 45 male students in the second grade physical education classes at Westwood Elementary School in Stillwater, Oklahoma. This physical education program at Westwood consisted of three classes weekly, thirty minutes in duration, for each second grade pupil. Convience samplings were used to divide the subjects into the control group and the experimental group.

Equipment

The following items were needed to conduct the study:

1) a tensiometer (Pacific Scientific Company Model: T5-6007-114-00) with a 2-100 pound indicator which was used to record flexion strength.

2) a testing table which was designed for the purpose of testing ankle dorsal and plantar flexion strengths, as noted in Clarke (65) and Clarke and Clarke (74).

3) a chain, 1/16 inch cable, stirrup strap and regulation strap which were needed to perform ankle strength testing.

4) a stabilometer with a Lafayette 1/1000 second clock and a trial clock was used to measure dynamic balance.

5) scorecards (refer to Appendix A) and pencils which were used to record results.

6) a shoulder brace as designed by Clarke and Munroe (64) which was used to maintain proper body position during the ankle plantar flexion strength test.

7) a goniometer for measuring the angle between the foot and the leg.

General Procedures

When the researcher met with the subjects for the first time an introductory letter was read to the class and discussed (refer to Appendix B). The subjects were requested to take the letter home for their parents' information. Also, at this time the children were shown the equipment along with a brief demonstration of how it would be used. It was hoped that this procedure would reduce anxiety that could have adverse effects on test results.

All testing was administered during the subjects' normal physical education classes. The stabilometer and testing table were in separate rooms out of sight from the students participating in class. Each subject entered the testing room individually to eliminate the effect of possible covert learning, and completed all trials before leaving. Knowledge of results were confidential and not reported to the participant during testing.

Two groups were used in this study. The experimental group consisted of twenty male subjects who performed specific ankle-strengthening exercises as part of their physical education class. Twenty-two members of the control group participated in their physical education class without specific ankle-strengthening exercises. Not counted in these groups were one subject from the experimental group and two subjects from the control group who transferred to other schools after the pretest. The experimental group had a treatment period of eight weeks.

Graduate Teaching Assistants from the School of Health, Physical Education and Leisure Services at Oklahoma State University assisted in the testing program. These assistants were individually trained on the proper testing procedures, use and maintenance of the equipment. The training procedure consisted of a demonstration of how to set the equipment up, how to make accurate readings and how to administer the tests. Each assistant took the test and practiced administering the test until the procedures were mastered.

Descriptions of Test Items

1) Stabilometer. Dynamic balance was tested using a stabilometer designed and constructed by Dr. O. D. Wikoff of the School of Health, Physical Education and Leisure Services, Oklahoma State University (Figure 1). The stabilometer was built with a balance platform directly above a rod that serves as a center of rotation with a 1¼ inch fulcrum.

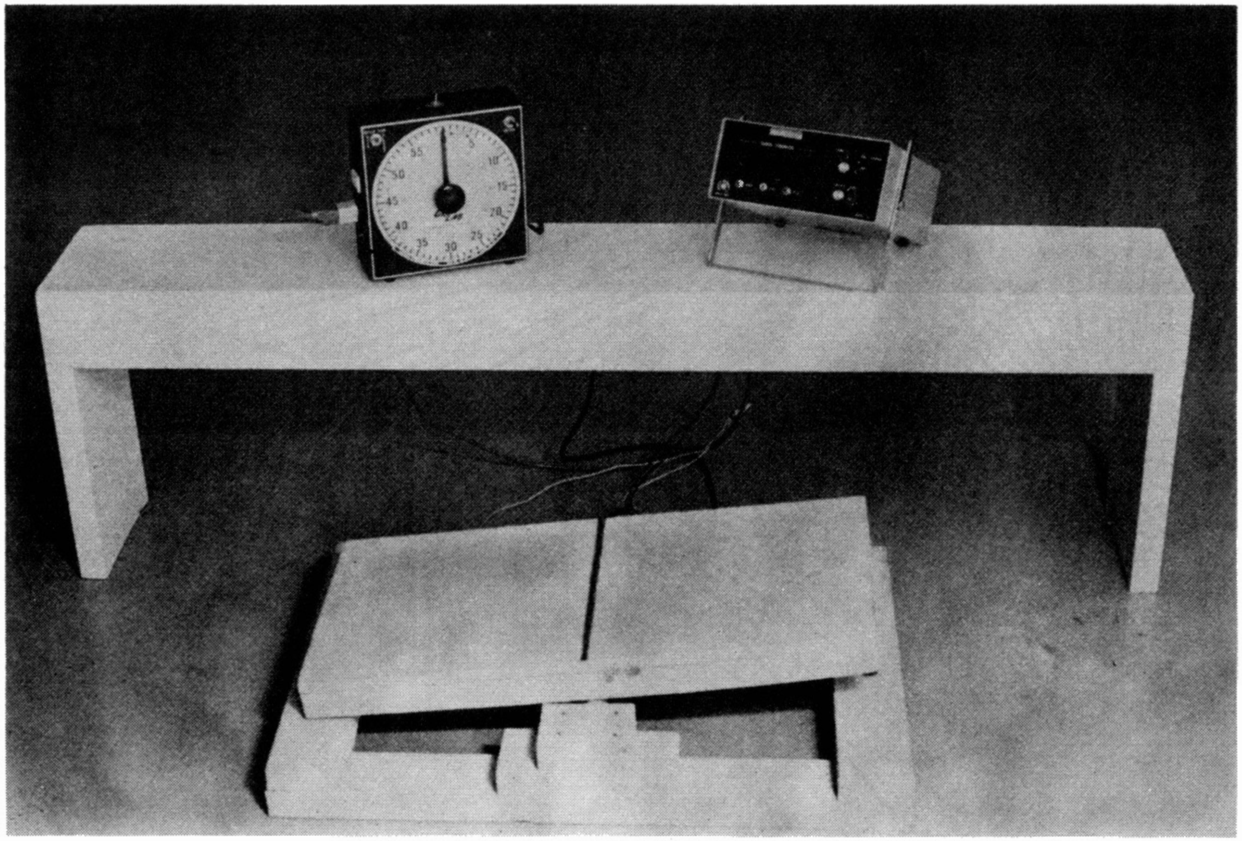

Figure 1. Stabilometer, Score Clock, and Trial Clock

Microswitches were attached to the base of the apparatus and beneath each end of the platform. The microswitches were electrically wired to a 60-second electric timer which was used to test each trial. The timer was set for 20-second trials and started manually. Once started the trial clock ran continuously for 20 seconds. At the end of 20 seconds the trial clock stopped automatically. A digital score clock which stopped when the trial clock stopped was used to record time off-balance. The score clock ran only when the trial clock was in operation and when either side of the platform was resting on a microswitch. The score clock registered time off-balance to the nearest tenth of a second, which the researcher converted to time on-balance by subtracting the recorded time off-balance from the 20 second time trial.

Each subject received three 20-second distributed trials with a 20 second rest interval between each trial. Husak and Magill (60) used this trial method in their study of first, second and third graders with the criterion score as the total of the three scores. The total on-balance time was the criterion score used in this study.

Instructions for each subject were standardized and given to the subject before testing. He was instructed to remove his shoes and was tested in his socks. Every subject was informed that all test results were confidential and will be used only for the purpose of this study. Verbal signals were used to start and stop each trial. No other verbal interaction occurred during the trial.

A straight red line was drawn on the platform of the stabilometer over the rod which was the center of rotation. The subject mounted the apparatus with his feet perpendicular to the red line and approximately shoulder width apart. Before each trial and when the subject mounted the stabilometer from the rear, the platform was positioned in contact with the back microswitch. The joint center of the foot was described as the upper border of the talus bone which is approximately in line with the tuberosity of the fifth metatarsal (75). The researcher found the subjects' tuberosity of the fifth metatarsal by palpation of each foot and marked them with a color tape different from the color of the subjects' socks.

After mounting the stabilometer, the subject placed the tape on his sock in line with the red stripe on the platform. With the verbal signal "go," the subject was allowed to shift his weight forward to begin balancing on the platform. The trial and score clocks were started simultaneously with the verbal signal. When the trial clock stopped to indicate the end of the 20-second trial, the subject was told to stop and step off of the apparatus. A 20-second rest period for each subject followed each trial before the next trial began. The time of each trial was recorded to the nearest tenth of a second.

2) Strength. The tensiometer was used to measure the strength of ankle plantar flexion and ankle dorsal flexion of each foot. Clarke (66) had shown that this instrument is highly reliable when proper testing techniques and procedures are used by the researcher. He further stated that other researchers have obtained reliability coefficients above .90 using these procedures.

The subjects were given three trials with each foot beginning with the right and then alternating left, right, left, right, left. One maximum effort was given by the subject for each trial with approximately one minute rest for each foot between trials. Since muscular strength was defined by Oxendine (19) as the greatest force in a solitary muscular act, the criterion score was the best effort of the three trials for each foot. A second criterion score was a composite score of the best efforts of both the right and left foot. This score was a control for the difference of the dominate foot.

Ankle plantar flexion strength was measured with the subject in a supine position on the testing table and in firm contact with the shoulder brace (Figure 2). The legs were to be extended at the hip and knee, and the arms were folded across the chest. The 90-degree angle formed between the leg and foot was checked with a goniometer to insure the proper angle. A stirrup strap which was attached to a cable was placed over the ball of the foot. The cable was attached to a chain which was fastened above the head and on the side which was being tested. The tensiometer was placed on the cable near the middle between the head and foot of the subject. Scores from the tensiometer were read to the nearest whole number and converted to pounds using the tensiometer conversion chart.

Ankle dorsal flexion strength was measured with the subject in the same plantar flexion position, except the angle between the leg and foot was 125-degrees. A regulation strap placed around the upper surface of the foot at the level of the ball of the foot was connected by cable and chain at the foot end of the table. The tensiometer was located between the foot and the chain connection post.

On a verbal signal the subject was told to move the foot smoothly against the cable as though he was trying to break the strap. The subject was forewarned that very little movement will actually occur, but that he should continue until told to stop. When the pointer of the tensiometer terminated movement, the subject was told to stop and

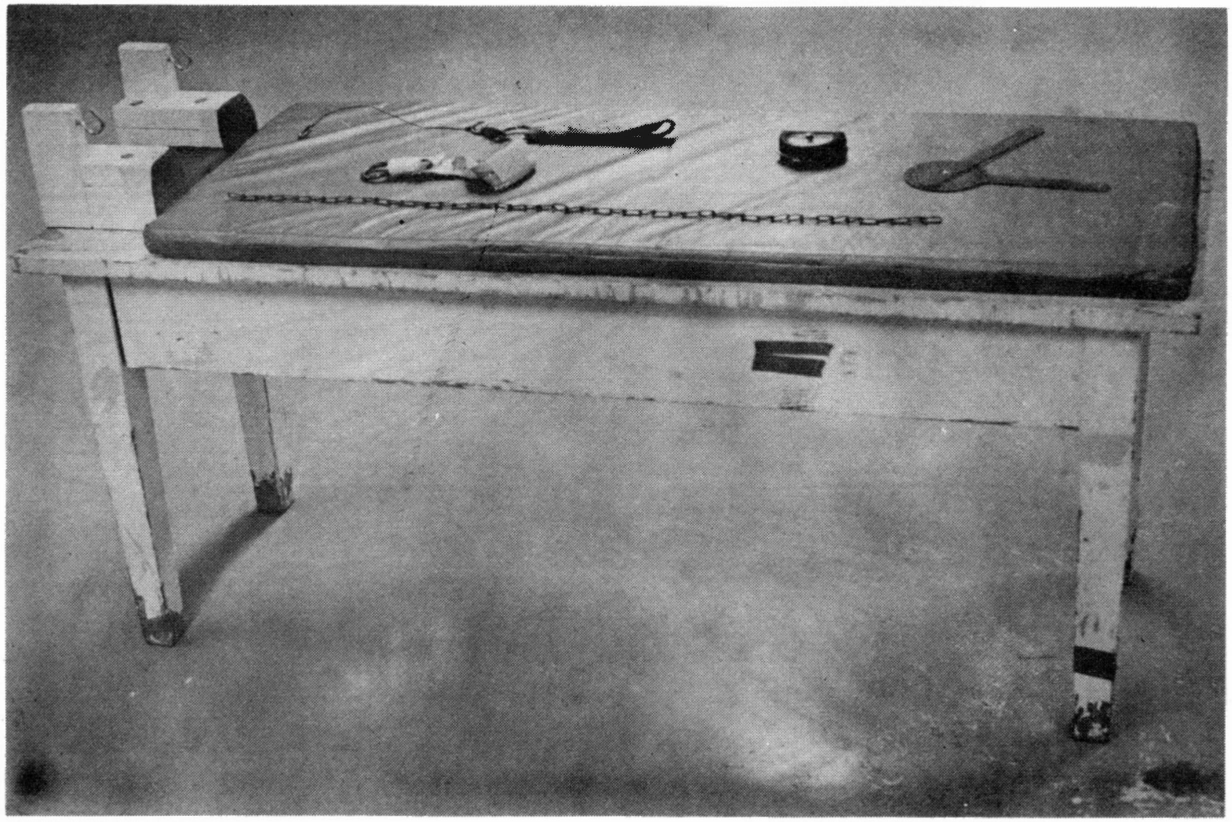

Figure 2. Testing Table, Cable and Regulation Strap, Stirrup Strap, Chain, Tensiometer and Goniometer

relax. This procedure was followed for all trials on both the right and left ankle.

Treatment

After pretesting was finished, the specific treatment for the experimental group was introduced which consisted of ankle exercises to perform during the first five minutes of each regular physical education class (refer to Appendix C). The control group participated with their regular physical education class without performing the ankle exercise. The physical education teacher, Mr. Dennis Cyr, controlled the activities of the class, and both groups took part in the same class activities.

The experimental treatment ended after eight weeks. At this time both groups were given a posttest which was under the same conditions as the pretest.

Treatment of Data

The Oklahoma State University Computer Center provided the statistical analysis of the data for this study. The Statistical Analysis System (SAS) was used to compute the Pearson product-moment correlation, the paired *t* test and the *t* test. The .05 level of confidence was used as the confidence level for accepting or rejecting the hypotheses.

CHAPTER IV

RESULTS

The primary purpose of this study was to determine the relationship of dynamic balance ability to measured strengths of ankle dorsal flexion and ankle plantar flexion in second grade boys. A secondary purpose was to determine if a significant difference existed between performance scores of the ankle exercise group and the non-exercise group. The subjects of this investigation were forty-five male students in the second grade physical education classes at Westwood Elementary School in Stillwater, Oklahoma. The total population of subjects was divided into the two groups according to convenience samplings of the physical education classes.

Descriptive Statistics

The data for this study were computer analyzed through the Statistical Analysis System (SAS) which provided statistics for the dynamic balance time and measures of ankle plantar and dorsal flexion strength. The program displayed the means, standard deviations, sums and minimum and maximum scores for each variable, which are presented in Table I through Table VI. Some interesting findings were cited as follows:

1) Time on-balance ranged from 23.8 sec. to 44.2 sec. The highest mean score (37.12 sec.) and the highest on-balance

TABLE I

DESCRIPTIVE STATISTICS FOR ENTIRE POPULATION
(PRETEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	45	35.02	4.74	23.80	41.90
Plantar Right (lb.)	45	47.55	15.02	25.00	87.50
Plantar Left (lb.)	45	46.47	15.20	18.40	85.00
Dorsal Right (lb.)	45	17.79	5.02	10.00	33.40
Dorsal Left (lb.)	45	15.83	5.08	5.00	33.40
Plantar Right and Left (lb.)	45	94.02	28.81	43.40	172.50
Dorsal Right and Left (lb.)	45	33.62	9.38	20.00	66.80

TABLE II

DESCRIPTIVE STATISTICS FOR ENTIRE POPULATION
(POSTTEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	42	36.58	3.55	28.70	44.20
Plantar Right (lb.)	42	53.66	14.77	30.00	82.50
Plantar Left (lb.)	42	56.90	15.18	30.00	87.50
Dorsal Right (lb.)	42	17.56	4.04	10.00	33.40
Dorsal Left (lb.)	42	16.19	3.80	6.60	25.00
Plantar Right and Left (lb.)	42	110.57	27.85	60.00	165.90
Dorsal Right and Left (lb.)	42	33.76	7.26	21.60	58.40

TABLE III

DESCRIPTIVE STATISTICS FOR THE ANKLE EXERCISE GROUP (PRETEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	21	35.28	4.60	24.80	41.50
Plantar Right (lb.)	21	41.14	11.14	25.00	60.00
Plantar Left (lb.)	21	41.02	14.92	18.40	67.50
Dorsal Right (lb.)	21	17.20	4.99	10.00	33.40
Dorsal Left (lb.)	21	14.36	3.64	5.00	20.00
Plantar Right and Left (lb.)	21	82.16	24.76	43.40	125.90
Dorsal Right and Left (lb.)	21	31.56	7.64	21.30	53.40

TABLE IV

DESCRIPTIVE STATISTICS FOR THE ANKLE EXERCISE GROUP (POSTTEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	20	37.12	3.86	28.70	44.20
Plantar Right (lb.)	20	53.57	15.08	30.00	82.50
Plantar Left (lb.)	20	56.96	15.21	30.00	82.50
Dorsal Right (lb.)	20	17.89	4.68	11.30	33.40
Dorsal Left (lb.)	20	16.30	3.37	10.00	25.00
Plantar Right and Left (lb.)	20	110.54	28.71	60.00	162.50
Dorsal Right and Left (lb)	20	34.18	7.62	23.80	58.40

TABLE V

DESCRIPTIVE STATISTICS FOR THE ANKLE
NON-EXERCISE GROUP (PRETEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	24	34.81	4.94	23.80	41.90
Plantar Right (lb.)	24	53.16	15.91	25.00	87.50
Plantar Left (lb.)	24	51.24	14.05	25.00	85.00
Dorsal Right (lb.)	24	18.30	5.09	11.30	33.40
Dorsal Left (lb.)	24	17.11	5.83	5.00	33.40
Plantar Right and Left (lb.)	24	104.40	28.53	56.70	172.50
Dorsal Right and Left (lb.)	24	35.42	10.50	20.00	66.80

TABLE VI

DESCRIPTIVE STATISTICS FOR THE ANKLE
NON-EXERCISE GROUP (POSTTEST)

Variables	N	Means	SD	Low Scores	High Scores
Balance (sec.)	22	36.09	3.25	29.60	42.20
Plantar Right (lb.)	22	53.75	14.84	31.70	82.50
Plantar Left (lb.)	22	56.85	15.52	31.70	87.50
Dorsal Right (lb.)	22	17.27	3.43	10.00	25.00
Dorsal Left (lb.)	22	16.10	4.23	6.60	23.40
Plantar Right and Left (lb.)	22	110.60	27.72	66.70	165.90
Dorsal Right and Left (lb.)	22	33.37	7.07	21.60	48.40

time (44.2 sec.) were recorded during the posttest for the ankle exercise group. The standard deviations were smaller on each posttest when compared with its respective pretest balance.

2) Plantar right scores ranged from 25.0 lb. to 87.5 lb. and plantar left had a low score of 18.5 lb. and a high of 87.5 lb.
3) The range of scores for dorsal right were from a low of 10.0 lb. to a high of 33.4 lb. Dorsal left ranged from 5.0 lb. to 33.4 lb.
4) The non-exercise group had higher scores on the plantar and dorsal pretest than the ankle exercise group. Mean scores for the ankle exercise group and non-exercise group respectively were 41.14 lb. to 53.16 lb. for plantar right, 41.02 lb. to 51.24 lb. for plantar left, 17.20 lb. to 18.30 lb. for dorsal right and 14.36 lb. to 17.11 lb. for dorsal left.
5) Plantar and dorsal flexion scores on the posttest were almost identical for both groups. Mean scores were 53.57 and 53.75 for plantar right, 56.96 and 56.85 for plantar left, 17.89 and 17.27 for dorsal right and 16.30 and 16.10 for dorsal left of the ankle exercise and ankle non-exercise groups respectively.

Correlations Between Variables and Balance

The SAS computer program was used to determine the correlations between dynamic balance and the variables of plantar right flexion strength, plantar left flexion strength, dorsal right flexion strength, dorsal left flexion strength, plantar right and left flexion strength and dorsal right and left flexion strength. The Pearson product-moment correlations statistical method was used to determine the degree of relationship between dynamic balance and the ankle strength variables. Possible correlation coefficients may range from -1.000 to +1.000 with a coefficient of .000 indicating no relationship between the two variables. The .05 level of confidence was considered to be significant.

Correlations for the entire population both pretest and posttest showed practically no relationship between dynamic balance and the different strength variables. Plantar right flexion strength had the highest coefficient with -.137 value and dorsal right and left had the lowest coefficient score of .001. Four negative coefficient values for balance were recorded on the pretest, while all six variables had negative coefficient values on the posttest. These negative values were too close to .000 to be meaningful. The results of these two tests are presented on Tables VII and VIII.

The ankle exercise group had the highest coefficient values, but only the plantar right flexion posttest when compared to balance approached the significant level. The plantar flexion values were all negative on the pretest while all the dorsal flexion values were positive. The strength variables on the posttest all had negative coefficients and were higher in value when compared with pretest results. These negative values indicated an inverse relationship for the strength variables and dynamic balance. Correlation information for the ankle exercise group has been recorded on Tables IX and X.

Pretest coefficient values were near .000 for all variables in the non-exercise group as shown in Table XI. These values indicated no relationship between the strength variables and dynamic balance.

TABLE VII

CORRELATION COEFFICIENTS FOR TOTAL POPULATION (PRETEST)

Variable	N	Balance (sec.)
Plantar Right (lb.)	45	-.062
Plantar Left (lb.)	45	-.036
Dorsal Right (lb.)	45	-.010
Dorsal Left (lb.)	45	.013
Plantar Right and Left (lb.)	45	-.051
Dorsal Right and Left (lb.)	45	.001

TABLE VIII

CORRELATION COEFFICIENTS FOR TOTAL POPULATION (POSTTEST)

Variable	N	Balance (sec.)
Plantar Right (lb.)	42	-.057
Plantar Left (lb.)	42	-.137
Dorsal Right (lb.)	42	-.075
Dorsal Left (lb.)	42	-.027
Plantar Right and Left (lb.)	42	-.105
Dorsal Right and Left (lb.)	42	-.056

TABLE IX

CORRELATION COEFFICIENTS FOR THE ANKLE EXERCISE GROUP (PRETEST)

Variables	N	Balance (sec.)
Plantar Right (lb.)	21	-.163
Plantar Left (lb.)	21	-.144
Dorsal Right (lb.)	21	.059
Dorsal Left (lb.)	21	.071
Plantar Right and Left (lb.)	21	-.160
Dorsal Right and Left (lb.)	21	.072

TABLE X

CORRELATION COEFFICIENTS FOR THE ANKLE EXERCISE GROUP (POSTTEST)

Variables	N	Balance (sec.)
Plantar Right (lb.)	20	-.394
Plantar Left (lb.)	20	-.253
Dorsal Right (lb.)	20	-.180
Dorsal Left (lb.)	20	-.180
Plantar Right and Left (lb.)	20	-.340
Dorsal Right and Left (lb.)	20	-.190

TABLE XI

CORRELATION COEFFICIENTS FOR THE ANKLE NON-EXERCISE GROUP (PRETEST)

Variables	N	Balance (sec.)
Plantar Right (lb.)	24	.020
Plantar Left (lb.)	24	.086
Dorsal Right (lb.)	24	-.055
Dorsal Left (lb.)	24	.007
Plantar Right and Left (lb.)	24	.053
Dorsal Right and left (lb.)	24	-.023

Correlations as derived from the posttest data have been recorded on Table XII. Plantar right flexion strength had the highest correlation coefficient with balance of the strength variables, but the .311 coefficient did not approach the significant level. Dorsal flexion values were all negative, and plantar flexion values were all positive.

Difference Between Pretest and Posttest Within Groups

The paired *t* statistical method was used to determine the difference between pretest and posttest improvement scores within groups. Steel and Torrie (76) indicated that this procedure increased the ability of the experiment to detect small differences and to exclude the inequalities of the two groups. The effects of the eight week treatment period were analyzed using the above mentioned statistical procedure. Figure 3 through Figure 7 have been constructed to display the mean dynamic balance and strength scores between the pretest and posttest for both the ankle exercise group and the non-exercise group.

The ankle exercise group showed improvement in all categories as indicated in Table XIII. Dynamic balance in this group had a 2.61 *t* which was significant at the .05 level. The pretest mean balance score was 35.28 sec. and the posttest mean score was 37.12 sec. All plantar flexion strength scores were significantly different at the .01 level between pretest and posttest scores. The highest *t* was recorded for plantar left improvement with a value of 9.75. While dorsal right and dorsal right and left did show some improvement, the amount of difference between tests was not significant. There was a significant difference for dorsal left improvement at the .01 level with a *t* value

TABLE XII

CORRELATION COEFFICIENTS FOR THE ANKLE
NON-EXERCISE GROUP (POSTTEST)

Variables	N	Balance (sec.)
Plantar Right (lb.)	22	.311
Plantar Left (lb.)	22	.058
Dorsal Right (lb.)	22	-.101
Dorsal Left (lb.)	22	-.243
Plantar Right and Left (lb.)	22	.200
Dorsal Right and Left (lb.)	22	-.195

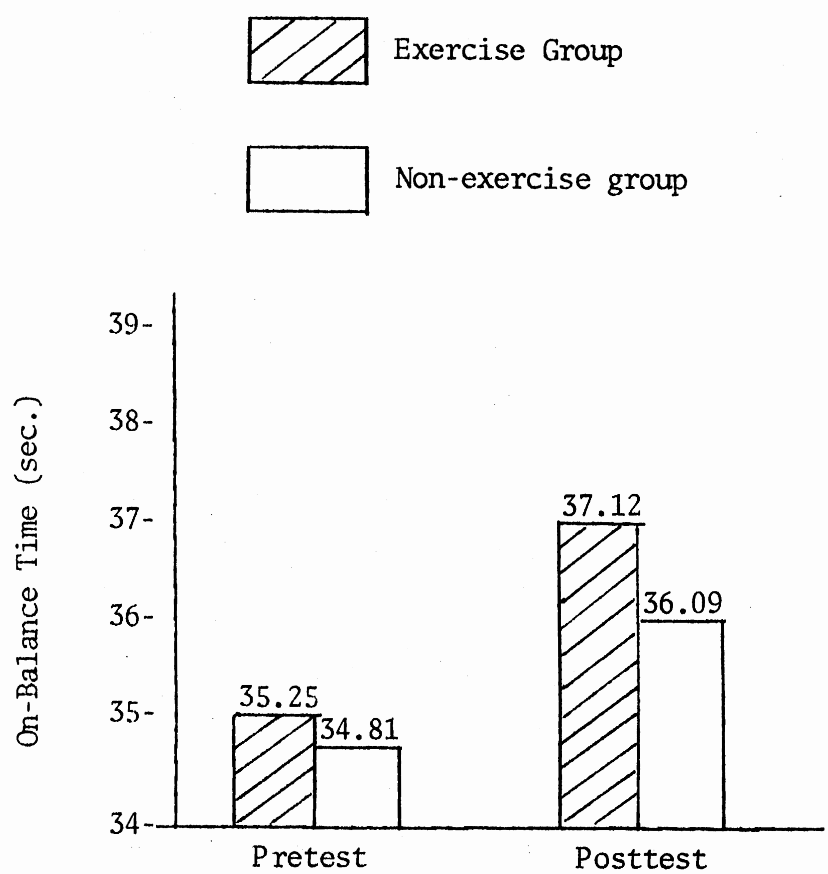

Figure 3. Mean Balance Scores

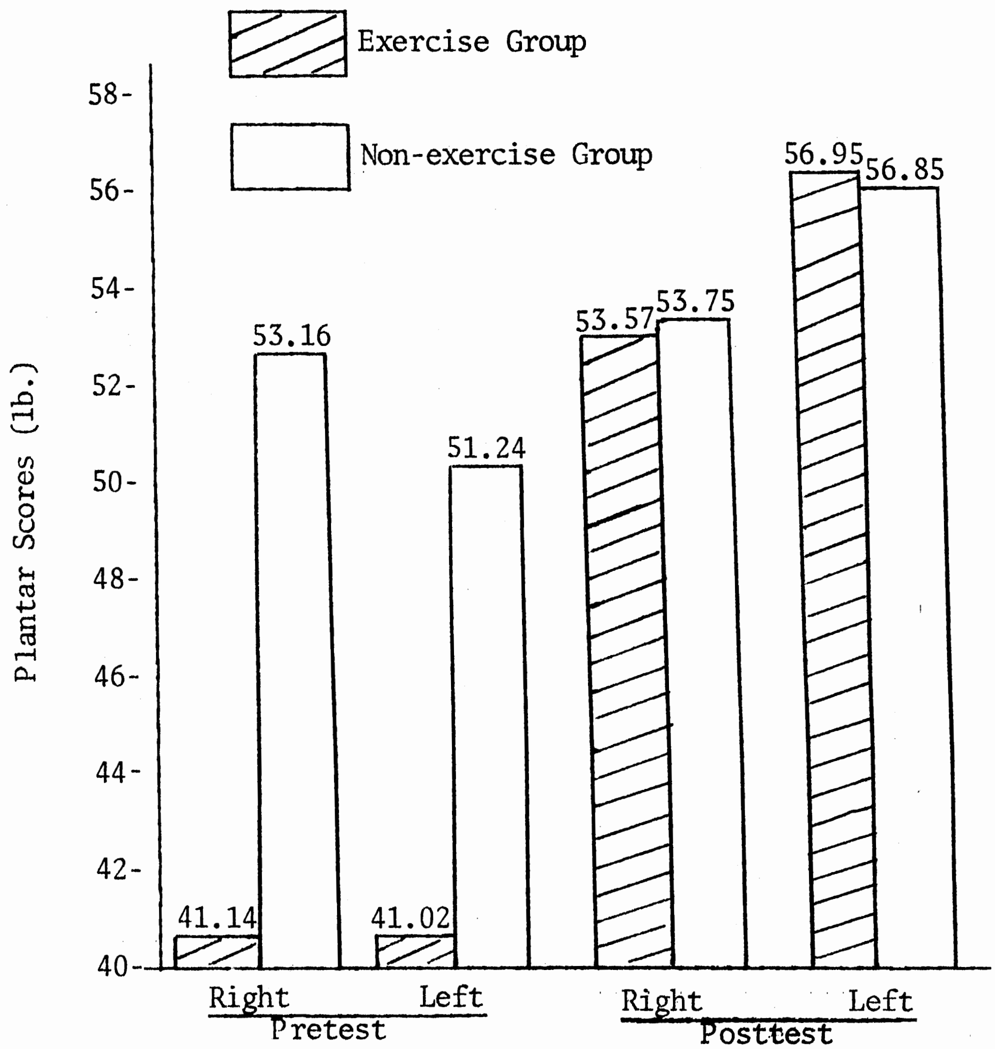

Figure 4. Mean Plantar Flexion Scores

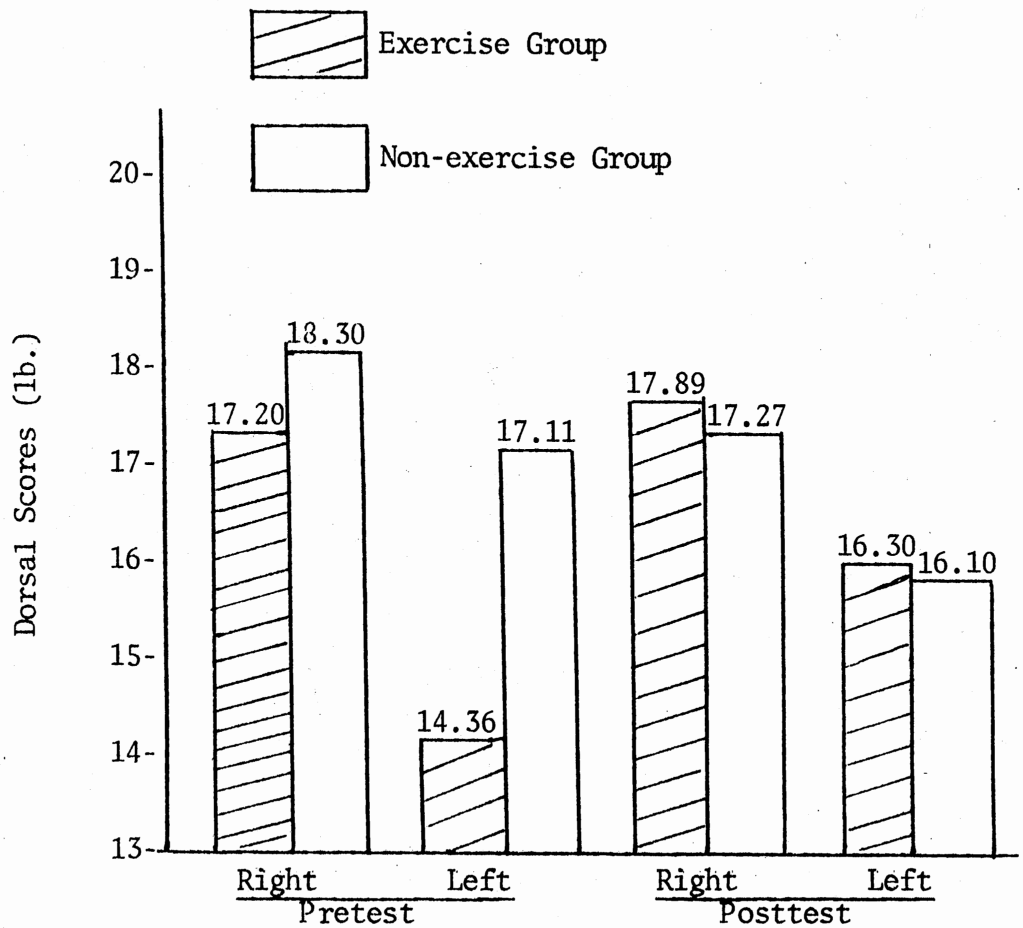

Figure 5. Mean Dorsal Flexion Scores

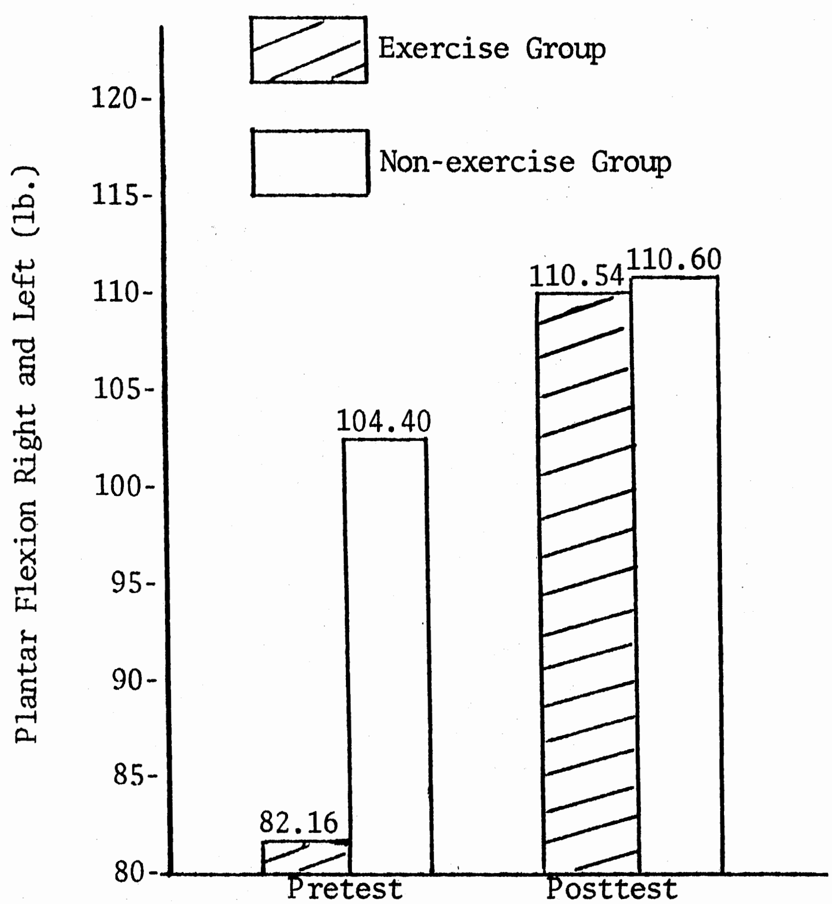

Figure 6. Mean Plantar Flexion Right and Left

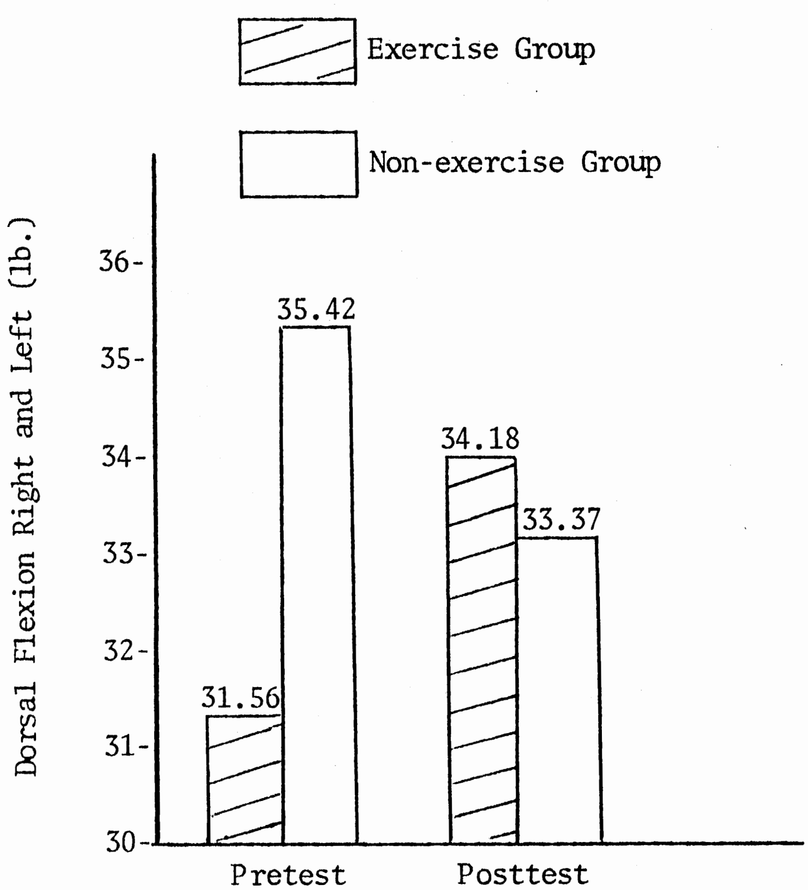

Figure 7. Mean Dorsal Flexion Right and Left

TABLE XIII

DIFFERENCE BETWEEN PRETEST AND POSTTEST MEANS FOR THE ANKLE EXERCISE GROUP

Variables	N	Mean of the Difference	Standard Deviation of the Difference	*t*
Basic Improvement (sec.)	20	1.77	3.03	2.61*
Plantar Right Improvement (lb.)	20	11.71	11.59	4.52**
Plantar Left Improvement (lb.)	20	14.98	6.87	9.75**
Dorsal Right Improvement (lb.)	20	0.52	4.82	0.48
Dorsal Left Improvement (lb.)	20	1.97	2.08	4.23**
Plantar Right and Left Improvement (lb.)	20	26.69	16.27	7.33**
Dorsal Right and Left Improvement (lb.)	20	2.49	6.16	1.81

*Significant at the .05 level of confidence.

**Significant at the .01 level of confidence.

of 4.23. The data in this study indicate that there was a significant difference between the subjects' scores on the pretest and posttest for the ankle exercise group.

The ankle non-exercise group showed varied results between pretest and posttest scores as recorded in Table XIV. Dynamic balance did increase between tests, but the mean of the difference between tests was only .80, which was not significant. All plantar flexion strength scores indicated some improvement. Plantar right improvement was very low while plantar left was significant at the .05 level. Decreases were found in the dorsal flexion strength scores between the pretest and posttest. These scores were lower, but none were significantly lower. This data indicated very little change between the pretest and posttest except for plantar left improvement. This increase in plantar left flexion strength may be attributed to the normal physical activity of the class.

Difference Between Groups

Differences between the two groups were calculated for improvement of dynamic balance, plantar flexion strengths and dorsal flexion strengths using the t test. A summary of this data is displayed in Table XV. The ankle exercise group increased their balance time more than the non-exercise group, but there was not a significant difference between groups. When analyzing plantar flexion improvement scores, there was a significant difference between groups at the .01 level. The ankle exercise group had a significant improvement in all plantar flexion scores as compared with the non-exercise group. Significant differences were also found between groups in measures of dorsal flexion

TABLE XIV

DIFFERENCE BETWEEN PRETEST AND POSTTEST MEANS
FOR THE ANKLE NON-EXERCISE GROUP

Variables	N	Mean of the Difference	Standard Deviation of the Difference	*t*
Balance Improvement (sec.)	22	0.80	4.72	0.79
Plantar Right Improvement (lb.)	22	0.01	13.37	.00
Plantar Left Improvement (lb.)	22	4.85	9.65	2.36*
Dorsal Right Improvement (lb.)	22	-0.67	2.82	-1.11
Dorsal Left Improvement (lb.)	22	-0.54	2.21	-1.14
Plantar Right and Left Improvement (lb.)	22	4.85	19.34	1.18
Dorsal Right and Left Improvement (lb.)	22	-1.20	4.27	-1.32

*Significant at the .05 level of confidence.

TABLE XV

MEAN OF THE DIFFERENCE FOR BOTH GROUPS

Variables	Exercise Group	Non-Exercise Group	t
Balance Improvement (sec.)	1.77	0.80	0.97
Plantar Right Improvement (lb.)	11.71	0.01	3.02**
Plantar Left Improvement (lb.)	14.98	4.85	3.88**
Dorsal Right Improvement (lb.)	0.52	-0.67	0.98
Dorsal Left Improvement (lb.)	1.97	-0.54	3.77**
Plantar Right and Left Improvement (lb.)	26.69	4.85	3.94**
Dorsal Right and Left Improvement (lb.)	2.49	-1.20	2.27**

*Significant at the .05 level of confidence.

**Significant at the .01 level of confidence.

strengths. The ankle exercise group showed improvement in dorsal left flexion which was significant at the .01 level and in dorsal left and right flexion which was significant at the .05 level when compared with the non-exercise group. There was not a significant difference between groups for dorsal right flexion improvement even though dorsal right flexion did improve for the ankle exercise group.

There was a significant difference between the two groups in every strength improvement variable but dorsal flexion right. The ankle exercise group did improve in strength and was significantly different from the non-exercise group. While dynamic balance did improve significantly within the ankle exercise group, there was no significant difference between the two groups.

Summary of Results

The primary purpose of this study was to determine the relationship of dynamic balance ability to measured strengths of ankle dorsal flexion and ankle plantar flexion in second grade boys. A secondary purpose was to determine if a significant difference existed between the ankle exercise group and the ankle non-exercise group.

Analysis of the data in this study revealed that there was practically no relationship between dynamic balance and the different strength variables. The .05 level of confidence was used as a criterion of significant correlation.

The ankle exercise group showed significant improvement between pretest and posttest for both dynamic balance and four of the six ankle flexion strength improvement variables. Dynamic balance improvement was at the .05 level, and the ankle flexion strength improvement variables were at the .01 level. The non-exercise group showed very little improvement or an actual loss in performance between pretest and posttest. An exception was plantar flexion left improvement which increased between tests significantly. Plantar flexion left improvement had a significant *t* of 9.75 for the ankle exercise group and 2.36 for the non-exercise group. This might be explained by the type of activities that took place in the regular physical education class and combining the ankle exercises for the experimental group. Plantar flexion left had the largest improvement for both groups.

The ankle exercise group did not significantly differ from the non-exercise group in measures of dynamic balance improvement. Balance improvement means were higher for the ankle exercise group but not at a significant level. Strength variables for the ankle exercise group did improve and all but one were significantly different from the non-exercise group.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

To enhance balance, physical educators have been exposing students to a wide variety of activities. In general, these learning activities have involved locomotor, nonlocomotor, manipulative, and balancing skills. Balance has been declared a very important element in proficient movement and should be a part of every elementary physical education program. Because balance is very important in motor learning, researchers need to explore other methods to improve balance in children.

The literature revealed few studies concerned with dynamic balance and strength. Most of these studies used college students as subjects. The only study located relating ankle strength to dynamic balance was concerned with adult women. Research using young children is lacking in this area, and also no study has determined if strengthening the ankles would further increase balance.

The primary purpose of this study was to determine the relationship of dynamic balance ability to measured strengths of ankle dorsal flexion and ankle plantar flexion in second grade boys. A secondary purpose was to determine if a significant difference existed between performance scores of the ankle exercise group and the non-exercise group.

Conclusions

Within the limits of this study the following conclusions based on the hypotheses were formulated:

1) There is no significant relationship between dynamic balance and ankle plantar flexion strength. A correlation coefficient at the .05 level of confidence was the acceptable level. This hypothesis was accepted. The correlations were very low and showed practically no relationship.

2) There is no significant relationship between dynamic balance and ankle dorsal flexion strength. A correlation coefficient at the .05 level of confidence was the acceptable level. This hypothesis was accepted. These correlations were even smaller and showed no relationship between dynamic balance and ankle dorsal flexion strength.

3) There is no significant difference between the control group and experimental group after the treatment period in measures of balance, dorsal flexion strength and plantar flexion strength. A significant difference was at the .05 level of confidence. This hypothesis was rejected. The *t* tests between groups indicated a significant improvement in plantar flexion strength and dorsal flexion strength. No significant difference was found between groups for dynamic balance but there was a difference within groups. The ankle exercise group had a significant improvement from pretest to posttest. While this was not significant between groups, it does give a trend in that direction.

From the results of this study, it was concluded that there was no relationship between dynamic balance and ankle plantar and dorsal flexion strength. It was also concluded that the treatment period did significantly improve ankle plantar and dorsal flexion strengths. Improving these strengths showed a trend in increasing dynamic balance but not at a significant level.

Recommendations

After extensive study of dynamic balance and ankle plantar and dorsal strengths, the following recommendations were made for further study:

1) The number of subjects and the length of the treatment period should be increased. This would be done to examine more closely the observation that improving ankle plantar and dorsal flexion strengths improves dynamic balance.
2) The same type of study utilizing female subjects, other grade levels and pre-school children.
3) A similar study with an ankle exercise group, balance activity group, ankle exercise and balance activity group and a control group.
4) Use of a balance beam test to measure dynamic balance as well as the stabilometer.
5) An equivalent study which would determine whether strength increases were due to internal muscle morphological changes or to motor learning. The next step would be to determine what effect morphological changes or motor learning have on dynamic balance.

6) A comparable study using torque instead of force pounds to measure ankle plantar and dorsal flexion strengths.

7) Research that would determine the ideal amount of muscular strength improvement to better enhance dynamic balance.

8) A study of kinesthetic awareness and how it is affected by increases in strength. If there is a change in kinesthetic awareness, the next step would be to determine what effect these changes have on balance.

9) A similar study using matched strength groups.

It was also felt by this author that elementary children should combine a wide variety of physical education activities with ankle strengthening exercises to enhance dynamic balance. More emphasis should be directed toward improving the ankle strength of the child in the primary grades. A five minute warm-up period at the start of each class with stretching and strength building exercises would be ideal. The child would then have time to participate in a wide range of activities to further enhance dynamic balance.

BIBLIOGRAPHY

1. Kirchner, Glenn. Physical Education for Elementary School Children. Dubuque, Iowa: Wm. C. Brown Company, 1974.

2. Drowatzky, John N. Physical Education for the Mentally Retarded. Philadelphia: Lea and Febriger Co., 1971.

3. Gallahue, David L. Motor Development and Movement Experiences for Young Children. New York: John Wiley and Sons, Inc., 1976.

4. Gallahue, D. L., P. H. Werner, and G. C. Luedke. Moving and Learning. Dubuque, Iowa: Kendall/Hunt Publishing Co., 1972.

5. La Brie, Vicki. Learning Disabilities Activity Guide for the Elementary Classroom. Maine State Department of Educational and Cultural Services, August, 1973-74.

6. Cratty, Bryant J. Perceptual and Motor Development in Infants and Children. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1979.

7. Corbin, Charles B. A Textbook of Motor Development. Dubuque, Iowa: Wm. C. Brown Co., 1973.

8. Lockhart, Aileene S. and Joann M. Johnson. Laboratory Experiments in Motor Learning. Dubuque, Iowa: Wm. C. Brown Co., 1970.

9. Winnick, Joseph P. Early Movement Experience and Development. Philadelphia: W. B. Saunders Co., 1979.

10. Drowatzky, John N. Motor Learning. Minneapolis: Burgess Publishing Co., 1975.

11. Austin Division of Curriculum Development. Approaches to Progress of Motor Development and Activities for Young Children. Austin, Texas: Texas Education Agency, 1977.

12. Singer, Robert N. Motor Learning and Human Performance. New York: MacMillan Publishing Co., 1975.

13. Thompson, Clem W. Manual of Structural Kinesiology. St. Louis: C. V. Mosby Co., 1977.

14. Logsdon, B. J. and others. Physical Education for Children: A Focus on the Teaching Process. Philadelphia: Lea and Febiger, 1977.

15. Stalling, Loretta M. Motor Skills. Dubuque, Iowa: Wm C. Brown Co., 1973.

16. Arnheim, D. D. and W. A. Sinclair. The Clumsy Child. St. Louis: C. V. Mosby Co., 1975.

17. Arnett, Chappelle and Margaret M. Thompson. Perceptual-Motor and Motor Performance Test Batteries Developed for Pre-School Through Grades Six Children. Columbia, Missouri University: Office of Education, February 1970.

18. Rasch, Philip J. and Roger K. Burke. Kinesiology and Applied Anatomy. Philadelphia: Lea and Febiger, 1974.

19. Oxindine, Joseph B. Psychology of Motor Learning. New York: Appleton-Century-Crofts, 1968.

20. Robb, Margaret D. The Dynamics of Motor-Skill Acquisition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972.

21. Meyers, Carlton R. Measurement In Physical Education. New York: Ronald Press Co., 1974.

22. Hunsicker, P. A. and R. J. Donnelly. "Instruments to Measure Strength." Research Quarterly, 26:408-420, December, 1955.

23. Clarke, H. H. "Comparison of Instruments for Recording Muscle Strength." Research Quarterly, 25:398-411, 1954.

24. Rarick, Lawrence and J. A. Thompson. "Roentgenographic Measures of Leg Muscle Size and Ankle Extensor Strength of Seven-Year Old Children." Research Quarterly, 27:321-332, 1956.

25. Berger, R. A. and L. A. Blaschke. "Comparison of Relationships Between Motor Ability and Static and Dynamic Strength." Research Quarterly, 38:144-146, March, 1967.

26. Conger, P. R. and R. B. McNab. "Strength, Body Composition, and Work Capacity of Participants and Non-participants in Women's Intercollegiate Sports." Research Quarterly, 38:184-192, May, 1967.

27. Maglischo, C. W. "Bases of Norms for Cable-Tension Strength Tests for Upper Elementary, Junior High and Senior High School Girls." Research Quarterly, 39:595-603, October, 1969.

28. Wyrick, Waneen. "Relationship of Ankle Strength and Test Order to Static Balance Performance." Research Quarterly, 40:619-624, 1969.

29. Carlson, B. R. and L. W. McCraw. "Isometric Strength and Relative Isometric Endurance." Research Quarterly, 42:244-250, October, 1971.

30. Di Nucci, J. M. and Shore, J. R. "The Construction of a Motor Fitness Test Battery for Boys in the Lower Elementary Grades." Paper presented at the Convention of the American Association for Health, Physical Education, and Recreation, Minneapolis, Minnesota, April 1973.

31. Rogers, F. R. "Physical Capacity Tests in the Administration of Physical Education," Contributions to Education, No. 173, cited by Meyers, C. R. Measurement in Physical Education. New York: Ronald Press Co., 1974.

32. Pennington, G. G., Drowatzky, J. N., Day, J. A., and J. F. Hanson. "A Measure of Handball Ability." Research Quarterly, 38:247-253, 1967.

33. Clarke, H. H. and E. W. Degutis. "Relationship Between Standing Broad Jump and Various Maturational, Anthropometric, and Strength Tests of Twelve Year Old Boys." Research Quarterly, 35:258-264, 1964.

34. Whitley, J. D. and L. E. Smith. "Influence of Three Different Training Programs on Strength and Speed of Movement." Research Quarterly, 37:132-142, 1966.

35. Carpenter, A. "Strength In Testing In the First Three Grades." Research Quarterly, 13:328-332, 1942.

36. Espenschade, A. S. and H. M. Eckert. Motor Development. Columbia, Ohio: Charles E. Merrill Publishing Co., 1980.

37. Alden, F. D., Horton, M. O., and G. M. Caldwell. "Motor Ability Test for University Women for Classification of Entering Students into Homogeneous Groups." Research Quarterly, 3:85-120, 1932.

38. Seashore, Harold G. "The Development of a Beam-Walking Test and Its Use in Measuring Balance in Children." Research Quarterly, 3:85-120, 1932.

39. Baumgartner, T. A. and A. S. Jackson. Measurement of Evaluation in Physical Education. Boston: Houghton Mifflin Co., 1975.

40. Di Nucci, J. M. Motor Performance Age and Race Difference Between Black and Caucasian Boys Six to Nine Years of Age. Stephen F. Austin State University, 1975.

41. Cron, G. W. and N. H. Pronko. "Development of the Sense of Balance in School Children." Journal of Educational Research, 51:33-37, 1957.

42. Wyrick, W. and C. Sanborn. "Prediction of Olympic Balance Beam Performance from Standardized Modified Test of Balance." Research Quarterly, 40:174-184, 1969.

43. De Oreo, K. L. "Dynamic Balance in Preschool Children: Quantifying Qualitative Data." Research Quarterly, 47:526-531, 1976.

44. Bachman, J. C. "Specificity Versus Generality in Learning and Performing Two Large Muscle Motor Tasks." Research Quarterly, 32:3-11, 1961.

45. Bachman, J. C. "Motor Learning and Performance as Related to Age and Sex in Two Measures of Balance Coordination." Research Quarterly, 32:123-137, 1961.

46. Williams, L. R. T. and V. Hearfield. "Heritability of a Gross Motor Balance Task." Research Quarterly, 44:109-112, 1973.

47. Bass, R. I. "An Analysis of the Components of Tests of Semicircular Canal Function and Static and Dynamic Balance." Research Quarterly, 10:33-52, 1939.

48. Ryan, E. D. "Motor Performance Under Stress As a Function of the Amount of Practice." Perceptual and Motor Skills, 13:103-161, 1961.

49. Roehrig, W. C. "Psychomotor Task With Perfect Recall After Fifty Weeks of No Practice." Perceptual and Motor Skills, 19:547-550, 1964.

50. Ryan, E. D. "Retention of Stabilometer Performance Over Extended Period of Time," Research Quarterly, 36:46-51, 1965.

51. Singer, R. N. "Effect of Spectators On Athletics and Non-Athletes Performing a Gross Motor Task." Research Quarterly, 36:473-482, 1964.

52. Melnick, M. J. "Effects of Overlearning On the Retention of a Gross Motor Skill." Research Quarterly, 42:60-69, 1971.

53. Bartz, D. W. and L. E. Smith. "Effect of Moderate Exercise On The Performance and Learning Of a Gross Motor Skill." Perceptual and Motor Skills, 31:187-190, 1970.

54. Brodie, David. "A Simple Stabilometer Modification for Qualitative Recordings." Research Quarterly, 47:850-851, 1976.

55. Rivens, R. S. "An Improved Stabilometer Task Apparatus." Research Quarterly, 13:328-332, 1942.

56. Travis, R. C. "An Experimental Analysis of Dynamic and Static Equilibrium." Journal of Experimental Psychology, 35:216-234, 1945.

57. Eckert, H. M. and R. G. Lawrence. "Stabilometer Performance of Educable Mentally Retarded and Normal Children." Research Quarterly, 47:619-623, 1976.

58. Stevenson, E. M. "Selected Variables Related to Children's Performance and Learning of a Balance Type Task." (Unpub. Ed.D. dissertation, Library, University of California, Berkeley, 1975.)

59. Lindsey, D. and J. O'Neal. "Static and Dynamic Balance Skills of Eight Year Old Deaf and Hearing Children." American Annals of the Deaf, 121:49-55, 1976.

60. Husak, W. S. and R. A. Magill. "Correlations Among Perceptual-Motor Ability, Self-Concept and Reading Achievement in Early Elementary Grades." Perceptual and Motor Skills, 48:447-450, 1979.

61. Horgan, James S. "Stabilometer Performance of Educable Mentally Retarded Children Under Differential Feedback Conditions." Research Quarterly, 48:711-716, 1977.

62. Eckert, H. M. and G. L. Rarick. "Stabilometer Performance of Educable Mentally Retarded and Normal Children." Research Quarterly, 47:619-623, 1976.

63. Johnson, B. L. and J. K. Nelson. Practical Measurement for Evaluation in Physical Education. Minneapolis: Burgess Publishing Co., 1975.

64. Clarke, H. H. and R. A. Munroe. Oregon Cable-Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College, Eugene, Oregon: University of Oregon, 1970.

65. Clarke, H. H. Muscular Strength and Endurance in Man. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966.

66. Jones, K. L. "Effects of Ankle Exercise on Ankle Flexibility and Vertical Jump Performance of Boys in Grade Four, Five, Six and Seven." (Unpub. Ed.D. dissertation, Library, University of New York at Buffalo, 1972.)

67. Pyfer, J. L. "Perceptual-Motor Dysfunction." Topic of Discussion of a "More Than One Way" Session, Wichita, Kansas, April 1973.

68. Gross, E. A. and H. L. Thompson. "Relationship of Modern Dance Performance to Agility, Balance, Flexibility, Power, and Strength." Research Quarterly, 37:313-316, 1966.

69. Bushey, S. R. "Relationship of Modern Dance Performance to Agility, Balance, Flexibility, Power, and Strength." Research Quarterly, 37:313-316, 1966.

70. Szymanski, J. A. "Restrictive Effects of Ankle Taping on Balance." (Unpub. M.S. thesis, Library, Washington State University, 1976.)

71. Kennedy, P. M. "The Effects of Weight Training and Weight Lifting on the Balance of Fifteen-Year-Old Male High School Students." (Unpub. M.S. thesis, Library, Pennsylvania State University, 1978.)

72. Beebe, E. L. "Motor Learning of Children in Equilibrium in Relation to Nutrition." Genetic Psychology Monographs, 15:99-242, 1934.

73. Laney, S. A. "Anthropometric and Strength Correlates of Dynamic Balance." (Unpub. Ph.D. dissertation, Library, The University of Texas, 1973.)

74. Clarke, H. H. and D. H. Clarke. Developmental and Adapted Physical Education. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963.

75. Barham, J. N. Mechanical Kinesiology. St. Louis: The C. V. Mosby Co., 1978.

76. Steel, R. G. D. and J. H. Torrie. Principles and Procedures of Statistics. New York: McGraw-Hill Book Co., 1960.

APPENDICES

APPENDIX A

SCORE SHEET

Name________________________ Code____________________

Class Time____________________

Dynamic Balance						Scoring
	Trials					
	1	2	3	Total	Converted	
Pre	____	____	____	____	______	Pre ______
Post	____	____	____	____	______	Post ______

Ankle Plantar					Scoring
	Pre Trials				
	1	2	3	Best	
Right	____	____	____	____	Pre Left ____
Left	____	____	____	____	Pre Right____
	Post Trials				
	1	2	3	Best	
Right	____	____	____	____	Post Right____
Left	____	____	____	____	Post Left____

Ankle Dorsal					Scoring
	Pre Trials				
	1	2	3	Best	
Right	____	____	____	____	Pre Left ____
Left	____	____	____	____	Pre Right____
	Post Trials				
	1	2	3	Best	
Right	____	____	____	____	Post Right____
Left	____	____	____	____	Post Left____

Plantar Combination	Scoring
Pre Best Right____ Best Left____ Total____	Pre Plan.____
Post Best Right____ Best Left____ Total____	Post Plan.____

Dorsal Combination	Scoring
Pre Best Right____ Best Left____ Total____	Pre Dorsal____
Post Best Right____ Best Left____ Total____	Post Dorsal____

APPENDIX B

LETTER TO PARENTS

January 4, 1980

TO: PARENTS/GUARDIAN

FROM: MR. DENNIS CYR
MRS. BARBARA BAYLESS

SUBJECT: TESTS OF BALANCE AND ANKLE STRENGTH
BY OSU PHYSICAL EDUCATION TEACHER

In a continuing effort to improve the quality of instruction in elementary physical education, to expand the existing knowledge of motor development in young children and to find other teaching methods, Mr. Bill Carleton will be testing the balance and ankle strength of our second graders. The tests, given in January and March, will take very little time from the children's physical education period.

If you have questions concerning this study, we will be glad to answer them. Your cooperation is appreciated.

Mr. Carleton's business telephone number is 624-5508.

APPENDIX C

ANKLE EXERCISES

Experimental Group Specific Ankle Exercises

1. Elevators: The elevator exercise is performed by rising high on the toes and then lowering the heels to the floor. The subjects will perform 20 elevators with the balls of their feet on a one inch block. The block will be located next to the wall so the subjects may use the wall to help steady their movement.

2. Isokinetic Exercise: The subjects will move their ankles through the entire plantar and dorsal flexion range of motion against a moderate force. This partner exercise will be performed with the subjects in a supine position with the hips flexed at a 90 degree angle to the floor and the lower leg parallel to the floor. The partners will place the soles of their feet together, and this position will be secured by a rubber strap. The non-exercising partner will exert moderate resistance to the subject going through the range of motion. The exercising subject will complete six repetitions of this exercise.

APPENDIX D

RAW DATA FOR VARIABLES

PRETEST FOR ANKLE EXERCISE GROUP

I.D.	Balance	Plantar Right	Plantar Left	Dorsal Right	Dorsal Left	Plantar	Dorsal
101	38.1	48.4	35.0	21.7	20.0	83.4	41.7
102	35.3	58.4	67.5	15.0	10.0	125.9	25.0
103	33.9	26.7	21.7	13.8	15.0	48.4	28.8
104	40.6	36.7	35.0	10.0	12.5	71.7	22.5
105	31.4	43.4	52.5	20.0	16.7	95.9	36.7
106	24.8	50.0	61.7	13.8	15.0	111.7	28.8
107	37.2	43.4	41.7	21.7	15.0	85.1	36.7
108	40.6	40.0	50.0	18.4	16.7	90.0	35.1
109	36.9	52.5	43.4	20.0	15.0	95.9	35.0
110	39.5	52.5	67.5	18.4	18.4	120.0	36.8
111	41.5	40.0	28.4	13.8	15.0	68.4	28.8
112	30.8	28.4	25.0	11.3	10.0	53.4	21.3
113	26.0	46.7	43.4	13.8	13.8	90.1	27.6
114	39.9	40.0	43.4	20.0	18.4	83.4	38.4
115	40.0	26.7	35.0	15.0	10.0	61.7	25.0
116	32.9	45.0	46.7	16.7	15.0	91.7	31.7
117	34.7	25.0	18.4	13.8	12.5	43.4	26.3
118	33.1	48.4	28.4	18.4	15.0	76.8	33.4
119	32.6	60.0	61.7	33.4	20.0	121.7	53.4
120	36.1	26.7	28.4	18.4	5.0	55.1	23.4
121	34.9	25.0	26.7	13.8	12.5	51.7	26.3

PRETEST FOR ANKLE NON-EXERCISE GROUP

I.D.	Balance	Plantar Right	Plantar Left	Dorsal Right	Dorsal Left	Plantar	Dorsal
201	31.4	63.4	65.0	15.0	12.5	128.4	27.5
202	40.1	52.5	56.7	13.8	11.3	109.2	25.1
203	30.6	38.4	56.7	15.0	15.0	95.1	30.0
204	30.2	43.4	45.0	12.5	11.3	88.4	23.8
205	36.5	63.4	58.4	21.7	15.0	121.8	36.7
206	37.3	87.5	85.0	20.0	21.7	172.5	41.7
207	40.6	60.0	56.7	21.7	15.0	116.7	36.7
208	34.4	40.0	40.0	18.4	16.7	80.0	35.1
209	38.6	52.5	58.4	21.7	21.7	110.9	43.4
210	35.0	63.4	67.5	23.4	23.4	130.9	46.8
211	35.7	58.4	45.0	25.0	21.7	103.4	46.7
212	39.1	31.7	31.7	15.0	18.4	63.4	33.4
213	41.4	25.0	33.4	16.7	20.0	58.4	36.7
214	36.8	52.5	43.4	11.3	12.5	95.9	23.8
215	37.7	58.4	60.0	20.0	21.7	118.4	41.7
216	23.8	85.0	67.5	21.7	21.7	152.5	43.4
217	37.0	63.4	56.7	20.0	18.4	120.1	38.4
218	32.3	63.4	63.4	15.0	15.0	126.8	30.0
219	27.0	31.7	25.0	15.0	5.0	56.7	20.0
220	41.9	50.0	41.7	15.0	12.5	91.7	27.5
221	33.9	63.4	38.4	15.0	13.8	101.8	28.8
222	28.1	35.0	48.4	21.7	21.7	83.4	43.4
223	28.0	35.0	33.4	11.3	11.3	68.4	22.6
224	31.0	58.4	52.4	33.4	33.4	110.9	66.8

POSTTEST FOR ANKLE EXERCISE GROUP

I.D.	Balance	Plantar Right	Plantar Left	Dorsal Right	Dorsal Left	Plantar	Dorsal
101	36.4	78.4	60.0	33.4	25.0	138.4	58.4
102	36.3	82.5	80.0	15.0	15.0	162.5	30.0
103	--	--	--	--	--	--	--
104	39.6	60.0	55.0	16.7	13.8	115.0	30.5
105	30.6	61.7	55.0	18.4	18.4	116.7	36.8
106	28.7	78.4	82.5	21.7	18.4	160.9	40.1
107	38.2	45.0	63.4	21.7	15.0	108.4	36.7
108	40.7	56.7	67.5	18.4	16.7	124.2	35.1
109	39.5	67.5	67.5	20.0	16.7	135.0	36.7
110	39.1	48.4	75.0	18.4	21.7	123.4	40.1
111	44.2	40.0	41.7	13.8	15.0	81.7	28.8
112	40.1	30.0	30.0	11.3	12.5	60.0	23.8
113	33.1	48.4	60.0	15.0	15.0	108.4	30.0
114	38.3	60.0	67.5	21.7	20.0	127.5	41.7
115	42.4	41.7	50.0	15.0	13.8	91.7	28.8
116	35.5	52.5	60.0	16.7	15.0	112.5	31.7
117	33.0	40.0	35.0	15.0	13.8	75.0	28.8
118	38.2	38.4	40.0	16.7	18.4	78.4	35.1
119	36.3	60.0	67.5	20.0	16.7	127.5	36.7
120	38.4	33.4	35.0	15.0	10.0	68.4	25.0
121	33.7	48.4	46.7	13.8	15.0	95.1	28.8

POSTTEST FOR ANKLE NON-EXERCISE GROUP

I.D.	Balance	Plantar Right	Plantar Left	Dorsal Right	Dorsal Left	Plantar	Dorsal
201	40.3	48.4	60.0	15.0	15.0	108.4	30.0
202	42.2	61.7	61.7	13.8	11.3	123.4	25.1
203	35.5	63.4	63.4	18.4	13.8	126.8	32.2
204	34.1	35.0	31.7	15.0	12.5	66.7	27.5
205	38.1	38.4	67.5	20.0	15.0	105.9	35.0
206	39.9	82.5	78.4	15.0	20.0	160.9	35.0
207	38.3	58.4	56.7	18.4	15.0	115.1	33.4
208	36.7	38.4	52.5	18.4	15.0	90.9	33.4
209	30.8	50.0	60.0	18.4	18.4	110.0	36.8
210	38.4	82.5	67.5	21.7	20.0	150.0	41.7
211	34.1	41.7	35.0	18.4	21.7	76.7	40.1
212	38.5	48.4	38.4	15.0	12.5	86.8	27.5
213	29.6	31.7	45.0	13.8	16.7	76.7	30.5
214	35.0	50.0	48.4	10.0	12.5	98.4	22.5
215	36.5	63.4	63.4	25.0	23.4	126.8	48.4
216	32.3	67.5	78.4	23.4	23.4	145.9	46.8
217	39.4	48.4	58.4	18.4	16.7	106.8	35.1
218	33.6	78.4	87.5	18.4	18.4	165.9	36.8
219	34.3	38.4	38.4	15.0	6.6	76.8	21.6
220	36.4	58.4	45.0	15.0	12.5	103.4	27.5
221	37.7	52.5	38.4	15.0	13.8	90.9	28.8
222	32.2	45.0	75.0	18.4	20.0	120.0	38.4
223	--	--	--	--	--	--	--
224	--	--	--	--	--	--	--

VITA

William Lyle Carleton

Candidate for the Degree of

Doctor of Education

Thesis: DYNAMIC BALANCE AND ANKLE PLANTAR FLEXION AND DORSAL FLEXION STRENGTH IN SECOND GRADE BOYS

Major Field: Higher Education

Minor Field: Health, Physical Education, and Recreation

Biographical:

Personal Data: Born in Richmond, Virginia, November 15, 1943, the son of Mr. and Mrs. M. L. Carleton. Married Nancy Jo Carleton May 12, 1979.

Education: Attended many elementary and junior high schools due to father's career in the Air Force; graduated from Enid High School in 1961; received the Bachelor of Science degree from Phillips University, Enid, Oklahoma, in 1965; received the Master of Education in Physical Education degree from Indiana University, Bloomington, Indiana, in 1973; and completed requirements for Doctor of Education degree in July, 1980.

Professional Experience: Taught elementary physical education and coached in Great Bend, Kansas, 1971-1977; head of the physical education department (K-12), 1973-1977; taught courses for Barton County Community Junior College and Fort Hays State College, 1974-1977; received graduate assistantship from Oklahoma State University to work toward Ed.D. degree, 1977-present. Member of the American Alliance of Health, Physical Education, Recreation and Dance and the OAHPER.