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The effect of multi-plane medicine ball exercise on core stability as measured by the Stabilometer®

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To the Graduate Council:

I am submitting herewith a thesis written by Gary L. Hall entitled "The effect of multi-plane medicine ball exercise on core stability as measured by the Stabilometer®." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Human Performance and Sport.

Wendell Liemohn, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Wendell Liemohn, Major Professor

We have read this thesis
And recommend its acceptance:

Karen Goss

Lorna Swanson

Accepted for the Council:

Vice Provost and Dean of Graduate Studies

THE EFFECT OF MULTI-PLANE MEDICINE BALL EXERCISE ON CORE STABILITY AS MEASURED BY THE STABILOMETER®

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Gary L. Hall
May 2003

ABSTRACT

The purpose of this study was to compare the outcomes of two different abdominal fitness training regimens on their ability to stabilize the core as quantitatively measured by the Stabilometer®. Twenty-four healthy, college age men and women from the University of Tennessee Army Reserve Officer Training Corps (ROTC) program (mean age 22.4 years, 20 men and 4 women) volunteered to participate in this study. These cadets were already participating in a rigorous, thrice weekly exercise regimen, which emphasized sagittal plane abdominal strengthening exercises. Subjects were randomly assigned to either the medicine ball group, which performed multi-plane medicine ball exercises in addition to the existing exercise regimen or the control group, which continued to perform the existing thrice weekly, sagittal plane abdominal strengthening exercises for a period of six weeks.

Subjects underwent pre and post testing utilizing the Stabilometer®, a dynamic, stability platform originally engineered to measure standing balance. This platform was connected to a counter and timer that measured the number of times the platform moved outside a predetermined arc of 10 degrees, as well as the total amount of time the platform stayed out of the 10 degree arc in the 30 second testing period. Four different test positions, in supine and kneeling positions, captured data in the frontal, sagittal and transverse planes. Data were analyzed using pair-wise comparison t-tests. Level of significance was set at $\alpha = .05$.

The medicine ball intervention group improved significantly in 5 of the 8 tests, 3 in total amount of time out of the testing arc and 2 for the number of times out of the testing arc. However, the control group also improved significantly in 5 of the 8 tests, 2 in the total amount of time and 3 in the number of times.

The results of this study were inconclusive in suggesting that multi-plane medicine ball exercise improves core stability as measured by the Stabilometer®. A high degree of existing abdominal strength, coupled with an intervention of insufficient length and intensity may provide an explanation for the lack of significant difference found between the groups.

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CHAPTER I

INTRODUCTION AND BACKGROUND

Low Back Pain will affect 80% of the population at some point in their lifetime with a 30% occurrence on any given day (Waddell, 1998). Inadequate strength of the trunk muscles would appear to be associated with this development of chronic low back pain (Shirado et al., 1995). Hence, concentration of effort toward “core stability” has become a very common goal of rehabilitation and performance programs. Saal (1992) describes core stabilization as “the use of the muscular system to brace the spine and protect the motion segments against repetitive micro trauma and excessively high single-occurrence loads”.

The human spinal column, devoid of musculature, is incapable of carrying the physiological loads imposed on it. It has been shown experimentally that an isolated fresh cadaveric spinal column from T1 to the sacrum placed in an upright neutral position with sacrum fixed to the test table can carry a load of not more than 20 N (4.4 pounds) before it buckles and becomes unstable (Panjabi et al., 1988). Thus the spine is dependent upon the muscular system for support.

Trunk muscles have been divided into local and global muscles based on their role in stabilizing the trunk (Bergmark, 1989). Local muscles include: Multifidus, transversus abdominis, Intertransversarii (intersegmental), Interspinales (intersegmental), Longissimus thoracis (pars lumborum), Iliocostalis lumborum (pars lumborum), Quadratus lumborum (medial fibers), and Internal Oblique (fiber insertion into the lateral raphe of thoracolumbar fascia). Muscles of the global stabilizing system include:

Longissimus thoracis (pars thoracis), Iliocostalis lumborum (pars thoracis), Quadratus lumborum (lateral fibers), Rectal abdominis, External Oblique and Internal Oblique. In the theoretical model, the stability of the spine is increased with either increased antagonistic flexor extensor muscle co activation forces or increased intraabdominal pressure along with increased abdominal spring force (Cholewicki et al., 1999). Deep local stabilizing muscles, especially multifidus and transversus abdominis, mainly contribute to spinal stability, whereas global muscles are the prime movers of the trunk and do not support the spine segmentally (Panjabi, 1992; Panjabi, 1992).

In his landmark article, Panjabi (1992) lists the basic biomechanical functions of the spinal system as (a) one that allows movements between body parts, (b) carries loads, and (c) protects the spinal cord and nerve roots. Mechanical stability of the spine is necessary to perform these functions and therefore it is of fundamental significance to the human body. The spinal stabilizing system as conceptualized by Panjabi consists of three subsystems: passive, active and neural. The normal function of the stabilizing system is to provide sufficient stability to the spine to match the instantaneously varying stability demands due to changes in spinal posture, and static and dynamic loads. Under normal circumstances, within the physiological ranges of spinal movements and against normal spinal loads, these three subsystems are highly coordinated and optimized.

Panjabi (1992) theorizes that the initiating signals that determine the forces needed from the muscles in the spinal stabilizing system are in the passive system in the form of ligament deformation. He based this on cadaveric studies in which spines stripped of musculature exhibited measurable neutral zones. Throughout the neutral zone the reactive forces are small but yet the deformation of ligaments can be large. This leads to the hypothesis that deformations in the ligaments provide a more useful feedback signal than do forces for monitoring the requirements for spinal stability. The stability requirements are also dependent on the loads carried by the spine. Because the ligaments deform under load, they can sense the spinal loads. Thus, the deformations of soft tissues are capable of providing a comprehensive set of signals from which stability requirements may be determined. In addition to ligament deformation feedback, instantaneous muscle tension may be monitored by the muscle spindles and Golgi tendon organs and adjusted by the neural control unit in accordance with the requirements for stability (Panjabi, 1992). Under this theory the normal function of the stabilizing system of the spine involves monitoring tissue deformations and selecting the appropriate muscles and adjusting their tension to accommodate changes in physiological postures, spinal movements, and spinal loads.

The passive subsystem consists primarily of the vertebral bodies, zygapophyseal joints and joint capsules, spinal ligaments, as well as passive tension from the musculotendinous units (Panjabi, 1992). The passive subsystem plays its most important stabilizing role in the elastic zone of spinal range of motion (Panjabi et al., 1982) The relative contributions of structures to segmental stability have been investigated by serially cutting the structures (Haher et al., 1994; Sharma et al., 1995) and through mathematical modeling experiments (Panjabi et al., 1982; McGill, 1988) The posterior ligaments of the spine (interspinous and supraspinous) along with the zygapophyseal joints and joint capsules and the intervertebral discs are the most important stabilizing structures when the spine moves into flexion (McGill, 1988; Adams et al., 1980). End range extension is stabilized primarily by the anterior longitudinal ligament, the anterior aspect of the annulus fibrosus, and the zygapophyseal joints (Haher et al., 1994; Sharma et al., 1995). Rotational movements of the lumbar spine are stabilized mostly by the intervertebral discs and the zygapophyseal joints (Farfan et al., 1970). Side bending movements have not been studied extensively, but it appears that the intertransverse ligaments may play an important role in segmental stability for movement occurring in the frontal plane (Panjabi et al., 1982).

In the neutral zone of range of motion, the structures of the passive subsystem (e.g. ligaments and joint capsules) may also function as force transducers, sensing changes in position and providing feedback to the neutral control subsystem (Panjabi, 1992; Panjabi et al., 1982; Jiang et al., 1995). Evidence for this role is provided by anatomical observations of afferent nerve fibers capable of conveying proprioceptive information in most of the structures of the passive subsystem, including the intervetebral discs, the zygapophyseal joint capsules, and the interspinous and supraspinous ligaments (Indahl et al., 1997; Jiang et al., 1995). Injury to the passive subsystem appears to have important implications for spinal stability. Intervertebral disc degeneration or disruption of the posterior ligaments of the spine may increase the size of the neutral zone, increasing the demands on the active and neural control subsystems to avoid the development of segmental instability (Panjabi, 1992; Panjabi et al., 1989).

The active subsystem of the spinal stabilizing system consists of the spinal muscles and tendons. The active and neural control subsystems are primarily responsible for spinal stability in the neutral zone, where passive resistance to movement is minimal (Panjabi, 1992; Sharma et al., 1995). In experiments performed with the musculature removed, the lumbar spine is known to be highly unstable at very low applied loads, attesting to the importance of muscle activity for spinal stability (Nachemson, 1968; Panjabi et al., 1989). The relative importance of different muscle groups in providing stability for the lumbar spine has been a topic of much debate and (Crisco & Panjabi, 1991; Macintosh et al., 1993; Gracovetsky et al., 1985; Tesh et al., 1987).

Differing roles have been suggested for the deeper, unisegmental muscles and the more superficial multisegmental muscles such as the abdominal and erector spinae muscles (Bergmark, 1989; Crisco & Panjabi, 1991). The unisegmental muscles of the lumbar spine, such as the intertransversarii and interspinales muscles, are proposed to function primarily as force transducers, providing feedback on vertebral position and movements to the neural control subsystem (Panjabi, 1992). Evidence for this role is provided by the small size of these muscles, their close proximity to the center of rotation for spinal movements, and their high concentration of muscle spindles. (Bogduk, 1997; Peck et al., 1984).

The larger, multisegmental muscles are responsible for producing and controlling major movements of the lumbar spine; they do not exhibit specific intersegmental control. Lifting and rotational movements have been studied most extensively because these are tasks frequently performed by the lumbar spine. The lumbar erector spinae muscle group provides most of the extensor force required for lifting tasks (Bogduk et al., 1992). Rotation is produced primarily by the oblique abdominal muscles (Macintosh et al., 1993). The oblique abdominals and the majority of the lumbar erector spinae muscle fibers lack direct attachment to the lumbar spine motion segments, and therefore are unable to exert forces directly on individual motion segments. The multifidus muscle is better suited for the purpose of segmental control; it originates from the spinous processes of the lumbar vertebrae and forms a series of repeating fascicles attaching to the inferior lumbar transverse processes, the ilium, and the sacrum (Macintosh & Bogduk, 1986). They propose that the multifidus muscle functions as a stabilizer during lifting and rotational movements of the lumbar spine Stability of the lumbar spine during movements in the frontal plane has not been studied extensively; nevertheless, quadratus lumborum muscle has been proposed to be the primary active stabilizer for these movements (McGill et al., 1996).

The role of the abdominal muscles in spinal stability has been the topic of much debate. The abdominals have been proposed to play an important role in generating extensor force during lifting tasks, either by increasing intra-abdominal pressure or by creating tension in the thoracolumbar (lumbodorsal) fascia (Bartelink, 1957;Gracovetsky et al., 1985). However, subsequent research suggests that the abdominal muscles are only capable of generating a nominal force, particularly through the thoracolumbar fascia (Tesh et al., 1987; McGill & Norman, 1988). The abdominal muscles are primarily flexors and rotators of the lumbar spine (Macintosh et al., 1993), the oblique abdominals and particularly the transversus abdominis muscle, with its more horizontal orientation, is thought to contribute to spinal stability by creating a rigid cylinder around the spine that can increase its stiffness (Hodges & Richardson, 1996; Gardner-Morse & Stokes, 1998). This theory is supported by studies demonstrating continuous activity of the transversus abdominis muscle throughout flexion and extension movements of the lumbar spine (Cresswell et al., 1992).

The neural control subsystem is thought to receive input from structures in the passive and active subsystems in order to determine the specific requirements for maintaining spinal stability (Panjabi, 1992; Hodges & Richardson, 1996; Gardner-Morse & Stokes, 1995). Dysfunction in the neural control system may place other spinal structures at risk for injury (Panjabi, 1992). If proper functioning of the neural control system is not restored following an injury, the potential for reinjury may be heightened (Gardner-Morse & Stokes, 1995).

No specific research was found that links poor neuromuscular control with increased risk of an initial injury to the lumbar spine. However, several studies were found that have shown that patients with LBP often have persistent deficits in neuromuscular control, indicating that recovery of proper function of the neural control subsystem is not automatic following an initial injury (Hodges & Richardson, 1996; Luoto et al., 1996; Luoto et al., 1995; Nies & Sinnott, 1991; Hodges & Richardson, 1997). Other researchers have demonstrated increased postural sway and slower reaction times in patients with LBP when they are compared with subjects without LBP (Luoto et al., 1996; Luoto et al., 1995; Nies & Sinnott, 1991). Luoto et al (1996) found that improvements in reaction time correlated with reduced disability in patients undergoing rehabilitation. These results support the hypothesis that neuromuscular control deficits often exist following lumbar spine injury and that reduction in these deficits correlates with improvements in functional status.

The neural control system may play an important role in stabilizing the spine in anticipation of an applied load. Hodges and Richardson (Hodges & Richardson, 1996; Hodges & Richardson, 1997) reported that transversus abdominis and multifidus activity consistently precedes active extremity movement in subjects without LBP. This finding suggests that the neural control system normally anticipates the need for stabilization against the reactive forces from limb movements. The same investigators found that the contraction of the transversus abdominis was delayed in patients with active LBP, possibly indicating deficient neural control.

Tesh et al. (1987) reviewed the mechanism wherein the anterolateral abdominal wall muscles increased the stability of the lumbar region of the vertebral column by tensing the thoracolumbar fascia and by raising intra-abdominal pressure. Much of the recent research relating to the muscles and fascia of the posterior aspect of the vertebral column originated in the New Zealand lab of Nikoli Bogduk; this research will be summarized in the next 4 paragraphs.

RESEARCH FROM BOGDUK'S LAB

The thoracolumbar fascia has fibers posteriorly that are variable in direction and are arranged in more than a single lamina. The number of laminae is dependent on the spinal level; two laminae in the upper lumbar spine (L1-L3), three in the lower spine (L3-L5) and five in the sacral region (Bogduk, 1997). The major contributor to the posterior fascial layers is the aponeurosis of the latissimus dorsi muscle. The fiber direction in the posterior layer is different from the fibers of the internal oblique and transverses abdominis muscles.

This posterior layer is attached to the distal portion of the spinous processes of the upper lumbar vertebrae (L1-L3) by superficial fibers and to the spinous processes of the lower lumbar vertebrae (L4-L5) by deeper fibers. At the level of the interspinous space, the deeper fibers of the fascia pass anteriorly to merge with the superficial fibers of the interspinous ligament at all lumbar levels. The fibers of the superficial lamina pass medially across the midline to blend with a similar band on the contralateral side. In the upper lumbar region (L1-L3) the superficial fibers cross the midline anterior to the supraspinous ligament whereas in the lower lumbar region (L4-L5), where the supraspinous ligament is absent, the lamina form the most dorsal structure. Contrary to many anatomic texts, Bogduk revealed through an axial tomogram that on leaving the midline, the posterior layer of the thoracolumbar fascia ran posterolaterally and not laterally in the frontal plane.

The fibers of the middle layer of the thoracolumbar fascia are attached to the distal portion as well as the length of the transverse processes of the lumbar vertebrae. In the part of the transverse processes, the middle layer is composed of superficial and deep fibers, whereas in the medial region the fibers are associated with the intertransverse ligament and the arrangement of fibers was not distinguishable. The posterior surface of the middle layer passed directly into the posterior layer to constitute the deep lamina. These fibers form a continuous sheath around the erector spinae muscle from the transverse to spinous process. The more substantial anterior fibers of the middle layer pass through the lateral raphe to merge with the aponeurosis of the internal oblique and transversus abdominis muscles.

Further cadaveric work in this study revealed that tension might be created in posterior and middle layers of the fascia by a rise in paraspinal muscle activity. This activity increases intracompartmental pressure within the paraspinal space because when the erector spinae muscles contract there is an increase in cross section (Bogduk et al., 1992). As the middle and posterior layers of the thoracolumbar fascia, vertebral column, and the intertransversus and interspinous ligaments form a closed compartment around the erector spinae muscle group, hoop tension can be developed in the fascial layers. The potential of the posterior fascial layer to convert lateral abdominal muscle pull into a caudocranial tension on the spinous processes, resulting in their approximation (i.e., a nominal anti-flexion moment), enables the fascia to draw the spinous processs together.

PURPOSE

Core strength and core stability have become buzzwords in the development of training programs for not only individuals with low-back pain but also asymptomatic athletes. The popular literature contains numerous articles and seminars that extol the virtues of including multiplane medicine ball exercise in any existing abdominal strengthening regimen (Gambetta & Clark, 1998). However, a paucity of refereed journal articles exist that actually quantify the benefits of multiplane medicine ball exercise over more traditional sagittal plane regimens.

For this study a regimen of multi-plane medicine ball exercises was devised to ascertain if their inclusion in an existing, predominantly sagittal plane abdominal strengthening program would reveal any significant differences. The Stabilometer® would be used as the dependant variable for the 2 activities, medicine ball multi-plane exercise intervention and control.

Although there are numerous means to test the strength of the musculature of the trunk that serves as the basis for core strength and stability, these tests typically do not consider the neuromuscular control element that is crucial to these variables. The purpose of this study was to compare the outcomes of 2 different abdominal fitness training regimens on their ability to stabilize the core as quantitatively measured by the Stabilometer®.

CHAPTER II

METHODS

SUBJECTS

This study was approved by the University of Tennessee Institutional Review Board (IRB) prior to the initiation of any subject testing. The volunteer subjects were 24 healthy, college-age men and women enrolled in the University of Tennessee Reserve Officer Training Corps (ROTC) program. Exclusion criteria included subjects with either acute injury or chronic disorder of the shoulder or history of chronic back pain, or recurrent episodes of back pain. All subjects were between the ages of 21 and 27 with a mean age of 22.4 years. Twenty subjects were male and four were female.

EQUIPMENT

The equipment used to measure core stability in this study was a Stabilometer® (Lafayette Instrument, Lafayette, IN) and a multi-function timer/counter. The Stabilometer® is a dynamic, stability platform that was originally engineered to measure standing balance. The Stabilometer® was originally developed by Lafayette Instrument Co. to measure standing balance; however, its extreme sensitivity permits registration of any deviation from motionless posturing. Because of these attributes, and because it is of sufficient size to evaluate balance used in core stability training (e.g., quadruped), the ability to perform such activities on a Stabilometer® should be a good indicator of core strength/stability. In two investigations, this equipment has been used for the purpose of measuring core stability (Liemohn et al., 2002; Liemohn et al., in press). After placing a one-inch thick foam padding on what was the "standing surface," the Stabilometer® permits the measurement of balance of subjects as they assume quadruped and supine postures often used in lumbar stabilization training. The Stabilometer® is equipped with external sensors for the measurement of tilt in one plane. The sensors allow 5° of tilt to either side of the axis of rotation. Tilt of the platform beyond this 5-degree threshold initiates a recording of the timer and counter. The resulting data were (1) the number of episodes the board's angle exceeded 5° from center to either side and (2) the total elapsed time during the 30 second testing period that the board's angle exceeded this 10° arc. The 5° setting was calibrated between each subject using a fluid inclinometer.

TESTING

Each subject underwent an orientation session including an explanation of the study, the medical applications, the benefits subjects might expect to gain from participating in the study, and all requirements associated with the study. Subject confidentiality and rights were protected throughout the study. Subjects also read and signed an informed consent, that explained the study's benefits and risks, and made it clear that subjects were free to withdraw from the study at any time.

Upon arrival for testing, subjects were randomly assigned to either the experimental or control group. Each group consisted of 12 subjects (10 males and 2 females). The control and intervention groups followed the same protocol. Subjects performed four different test exercises, each performed for three trials, each lasting 30 seconds. The master time for each trial was kept using the multi-function counter/timer. Prior to the first administration of each test, the subjects were given a 20 second orientation trial. Immediately after this trial, the subject dismounted the Stabilometer® then returned to the instrument to begin the first trial. The 30-second data collection period began only after the subject was centered on the board, and gave a verbal signal as to their preparedness. Upon completion and dismount, the subjects were given a one-minute rest. They then performed the twenty-second orientation trial for the next exercise. The subjects performed the orientation trial, then the first data collection trial for each different exercise, and then they repeated each successive exercise without the 20-second orientation trial (i.e., three data collection trials per exercise). Brief corrections and advice to ensure that all subjects were similarly positioned and moving through similar ranges of motion were only given during the orientation trial.

The following four exercises were tested in this order:

1. **Dynamic Quadruped** (Figure A-14): The subject attempted to balance the board in a quadruped position while alternately lifting straight arms in the sagittal plane. The subject performed each arm movement to a metronome set at 40 beats per minute while attempting to maintain their balance on the Stabilometer® in the frontal plane, their body parallel to the axis of rotation.
2. **Kneeling Side Arm Raise** (Figure A-15): The subject attempted to balance the board in a kneeling position while alternately raising their arms in the frontal plane to shoulder level. The subject performed each arm movement to a metronome set

at 60 beats per minute while attempting to maintain their balance on the Stabilometer® in the frontal plane, their body parallel to the axis of rotation.

3. **Static Bridging** (Figure A-17): The subject isometrically bridged with the feet on the Stabilometer® platform parallel to the axis and the shoulders on a simple rocker board on a mat perpendicular to the platform. The mat was raised so the shoulders and feet were level to one another. The subject attempted to maintain their balance in the transverse plane.
4. **Dying Bug** (Figure A-16): The subject was supine, perpendicular to the axis of the platform with the legs bent and the heels tucked toward the gluteal fold, feet flat on the platform. Straight arms were raised overhead to shoulder level, the contralateral legs were raised and fully extended to the front in an alternating, reciprocal manner at 40 beats per minute. The subject attempted to maintain their balance in the sagittal plane.

TRAINING PROGRAM

Each of the study participants was in a mandatory preexisting exercise program that included several abdominal strengthening exercises performed 3-times per week. These exercises were predominately performed in the sagittal plane. Before departing from the initial orientation session, each subject in the experimental group received training in the proper technique for performance of their assigned abdominal strengthening program utilizing medicine balls.

Following the testing, the control group performed their existing physical training regimen with no alteration. This consisted of following a thrice weekly, callisthenic and running-based exercise program lasting approximately 60 minutes for each of the 3 periods. The focus of the abdominal exercise for this control group was on crunches and sit-ups. The reason for this focus was that the sit up is one of three portions of the Army Physical Fitness Test, which the cadets are expected to take at least biannually (U.S. Army, 1992).

The experimental group also maintained this existing physical fitness routine, however, in addition they performed the following four exercises with a 10-pound medicine ball thrice weekly:

1. **Supine Torso Raise** (Figure A-5): Subject was in the supine position, arms extended to 90° shoulder flexion holding a 10 lb medicine ball. Maintaining a neutral spine, the ball is raised toward the ceiling, with the spine at the approximate level of T4 moving four to six inches away from the floor. The subject performed 2 sets of 12 repetitions, with a 1-minute rest period between sets.
2. **Seated Torso Twist** (Figure A-6 to A-8): Subject sat on the floor with a neutral spine and the legs crossed. The medicine ball is held at the level of the chest, and the subject begins the exercise by twisting the torso to the left, placing the medicine ball on the floor directly behind them with both hands. The subject then twists the torso to the right and takes the ball from the floor behind them, returning

to the starting position with the ball held at chest level. 10 repetitions initiated in each direction counts as 1 set. Subjects completed 2 sets per session.

3. **Standing Torso Twist** (Figure A-9 to A-10): This partner-assisted exercise requires the subjects to stand upright, back-to-back with their spines in a neutral position. This exercise is similar to the Seated Torso Twist with the exception that the ball is passed to the partner instead of being placed on the floor. Similarly, 10 repetitions initiated in each direction counts as 1 set. Subjects completed 2 sets per session.
4. **Supine Leg Flexion** (Figure A-11 to A-13): Subjects were supine, knees flexed to 90°, with their arms at their sides resting on the mat. The medicine ball is held between the knees. The exercise is initiated with the subject flexing the hips toward the chest as far as possible, and then slowly lowering the legs back to the mat. The hips are again flexed but instead of being returned to the starting position, the knees are lowered to the left toward the mat. The knees are then returned to center and then lowered to the mat. This is then repeated towards the opposite side. Center, left and right are considered 1 repetition. Each subject completes 10 repetitions per exercise session.

DATA ANALYSIS

Data analysis was conducted on all the study participants, as all were 100% compliant with the tri-weekly training sessions. Data were analyzed using a paired sample t-test, pre and post intervention. The α level for all statistical tests was set at 0.05. All statistics were performed with Microsoft Excel 2000 (Microsoft Corporation, Redmond, WA) and SPSS for Windows version 9.0 (BioExchange, San Francisco, CA).

CHAPTER III

RESULTS

Based on the results, there were significant differences found within both the control and medicine ball intervention groups (Tables A-1 thru A-12). The medicine ball intervention group, within the variable Amount of time spent out of the 10 deg arc, displayed a significant difference in 3 of the 4 testing exercises (Tripod, .010; Arm Raise, .000 and Dying Bug, .039). The testing variable of Number of times out of the 10 deg arc, Medicine ball intervention group, revealed a significant difference in 2 protocols, (Arm Raise, .039 and Dying Bug, .025). However, although not statistically significant, the remainder of the testing exercises did reveal improvement amongst the medicine ball intervention group, with the exception of Bridging which had a slight rise in mean from pretest to posttest within the testing variable, Amount of time spent out of 10 deg arc.

The control group showed a significant difference in the 2 of 4 protocols within the variable Amount of time spent out of the 10 deg arc, (Tripod, .032; and Arm Raise, .002. The control group had 3 testing protocols (Tripod, .027; Arm Raise, .000 and Dying Bug, .012) within the variable Number of times out of the 10 deg arc that revealed significant differences. The control group also showed improvement in most of the testing protocols that were not statistically significant. The sole exception was again the Bridge, this time in the testing variable Number of times out of the 10 deg arc.

CHAPTER IV

DISCUSSION

The purpose of this study was to compare the outcomes of 2 different abdominal fitness training regimens on their ability to stabilize the core as quantitatively measured by the Stabilometer®. Participants in both the experimental and control group experienced statistically significant improvement in 3 of the 4 testing protocols for the amount of time spent out of the 10° testing arc (Tripod, Arm Raise, and Dying Bug). The experimental group, (i.e. medicine ball intervention), experienced a statistically significant difference from pre to post testing in only one of the number of times out of the testing arc, that being the Dying Bug. The control group exhibited a statistically significant difference in two of the number of times out of testing arc protocols, Tripod and Arm Raise (Figures A-1 thru A-4).

There are several potential explanations as to why the experimental group failed to significantly out perform the control. The existing high level of abdominal fitness amongst the study participants might have reduced the magnitude of the gains to be realized. The R.O.T.C. cadets who participated had been undergoing at a minimum a mandatory tri-weekly abdominal fitness regimen for several months, and in most cases, years. Additionally, the majority of the participants stated that prior to the study, they pursued alternate abdominal training outside of the aforementioned mandatory sessions. Thus, both group's margins for improvement might have been minimal.

The relative length of time of the intervention might also have had a direct bearing on the results. The intervention protocol consisted of tri-weekly sessions for 6 weeks. While there was 100% compliance from the study participants, due to their existing high level of abdominal strength, the total length or frequency might have been insufficient to achieve more definitive results. This frequency was chosen because it mirrors the abdominal strengthening programs of typical active-duty Army units. Along with the length and frequency, the relative intensity of the exercises (as described earlier) might have proven insufficient. Feedback from the participants indicates that a progressive increase in the number of repetitions and the weight of the medicine balls could have been easily tolerated. This was decided against prior to the execution of the study to ensure greater standardization and tolerance by all participants.

It was anticipated that the six week intervention period of the study would preclude any potential learning effect from the pre-test to the post-test testing. The mean values, particularly of the control group, would seem to indicate that in fact a degree of familiarity if not true learning did take place. As the pretest was the first time all the participants had encountered the Stabilometer®, it would seem possible that the study participants would be more at ease and have thought through certain balance strategies when encountering the Stabilometer® for post-testing.

As stated, the subject population consisted of R.O.T.C. cadets. This improves the homogeneity of the sample but diminishes the ability to generalize results of this study to older populations. However, it is felt that the results of this study are applicable to any healthy, athletic, college-age group. Especially representative would be the junior officer and enlisted members of the Armed Services. These are populations that are also actively engaged in abdominal strengthening as well. Currently there are approximately 220,000 junior enlisted soldiers in the U.S. Army (Army Situation Report, 1999). Their age range closely matches that of the subjects in this study. The implementation of this study's intervention was designed to mirror the existing structure of the type of physical fitness programs in which these young men and women are engaged.

There exist a number of areas for future research from this study. First, a similar longitudinal study should be conducted over a longer period of time (i.e., six months to one year). A study of longer duration perhaps would have shown a significant difference in experimental to control group means. Along with this, a study that more freely allows the participants to progress in intensity would be in order. Muscular fitness, as defined by the American College of Sports Medicine, is a combination of strength and endurance (ACSM, 2000). As a result, isotonic strengthening programs need to provide for a means to progress in both areas. The length of time and the inability to progress in resistance via the medicine balls would seem to be a contraindication from this study. A study that targeted a different population but used the same methods would also seem to be indicated. The greater disparity in fitness levels for an at risk population for low back pain (30-, 40-, 50-year range) might result in a more effective intervention. This could also encompass a participant population of similar age to the one in this study, which does not maintain as rigorous a physical fitness schedule as do these cadets.

CHAPTER V

CONCLUSION

The results of this study were inconclusive in suggesting that multi-plane medicine ball exercise improves core stability as measured by the Stabilometer®. Both the intervention and control groups displayed significant differences in pretest to posttest performance in several of the testing areas. A high degree of existing abdominal strength, coupled with an intervention of insufficient length and intensity might provide an explanation for these findings.

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APPENDICES

APPENDIX A - FIGURES

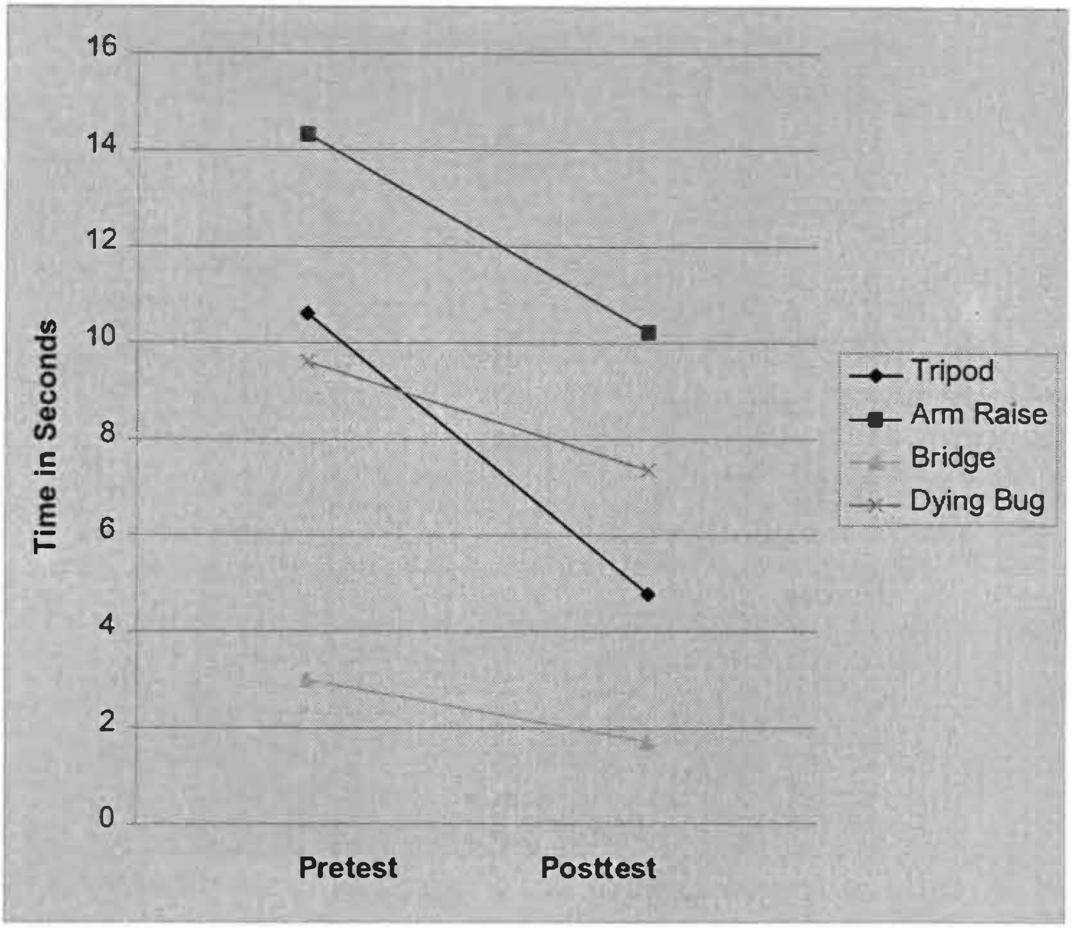

Figure A-1. Medicine Ball Group, number of times out of 10 deg arc.

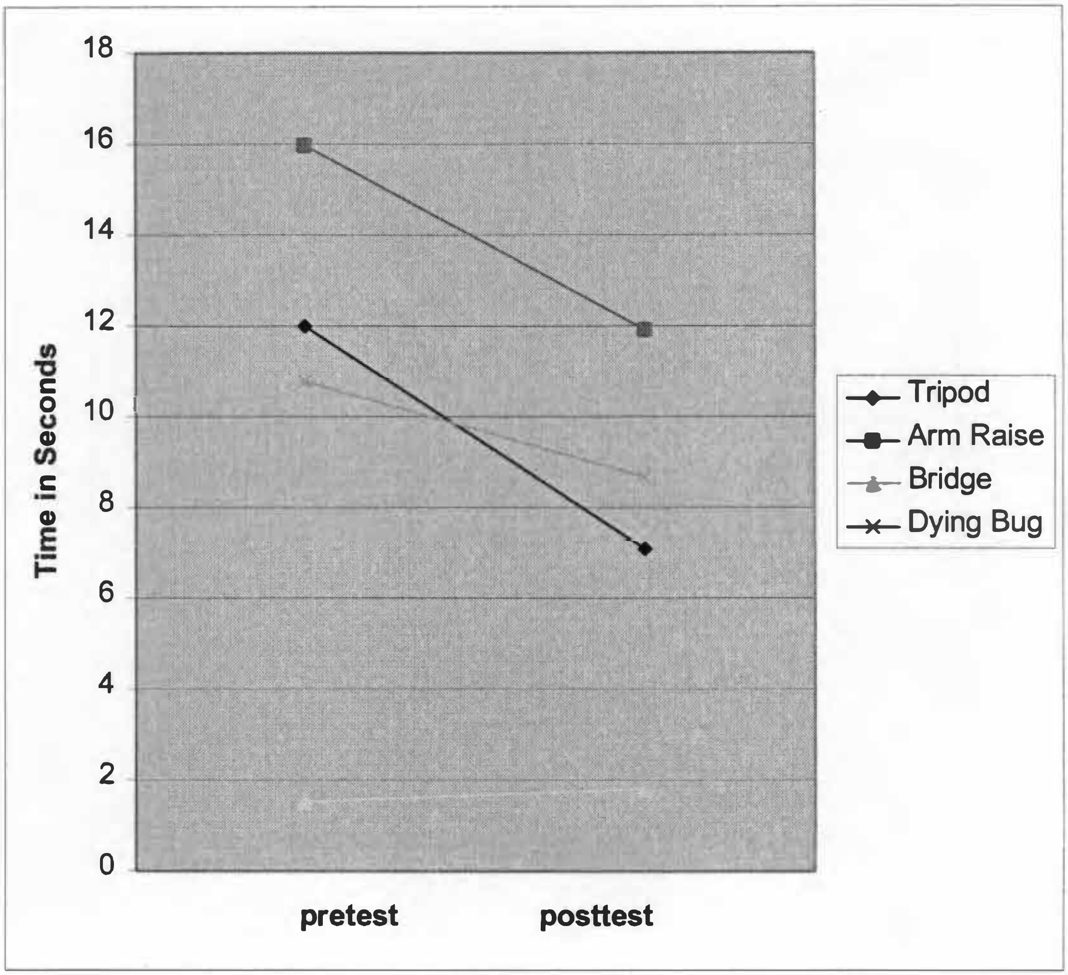

Figure A-2. Control Group, number of times out of 10 deg arc.

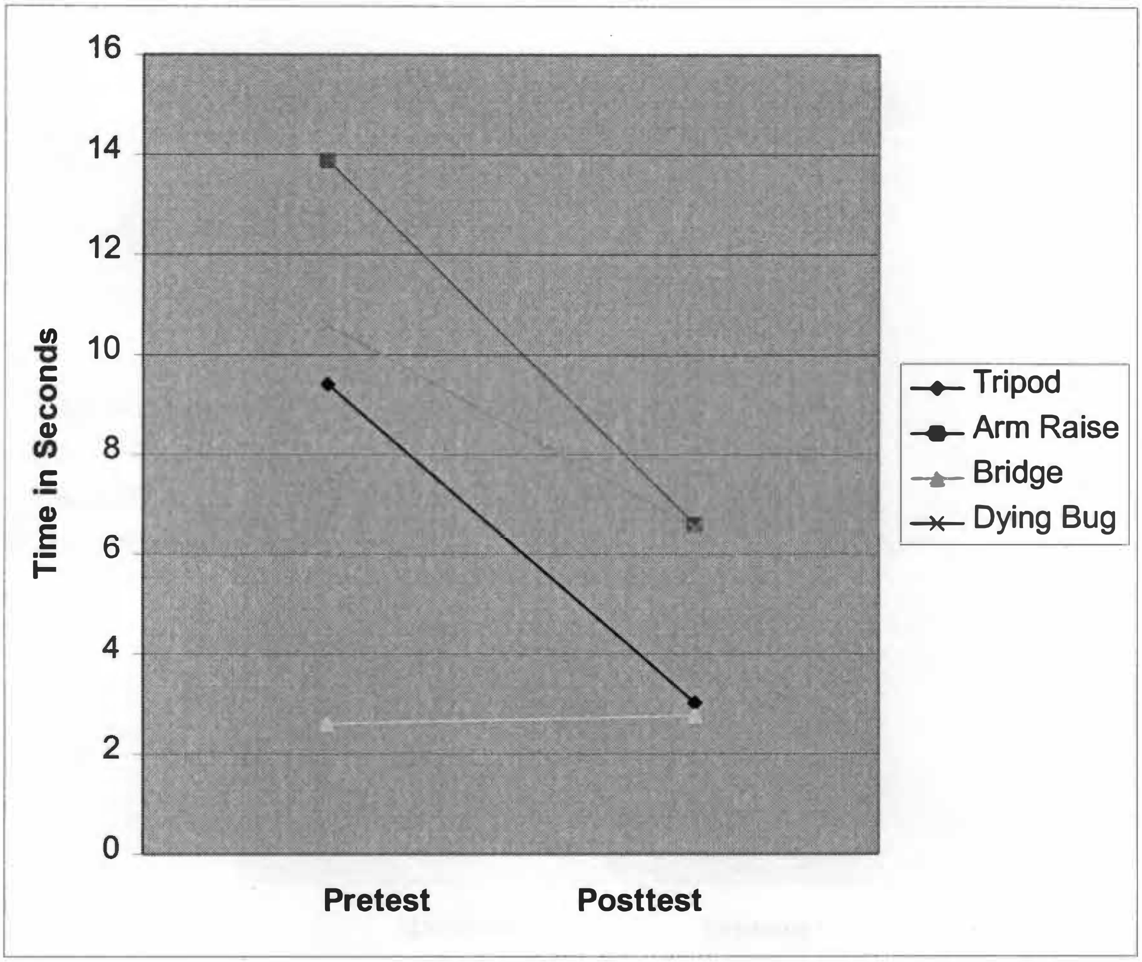

Figure A-3. Medicine Ball Group, amount of time spent out of 10 deg arc

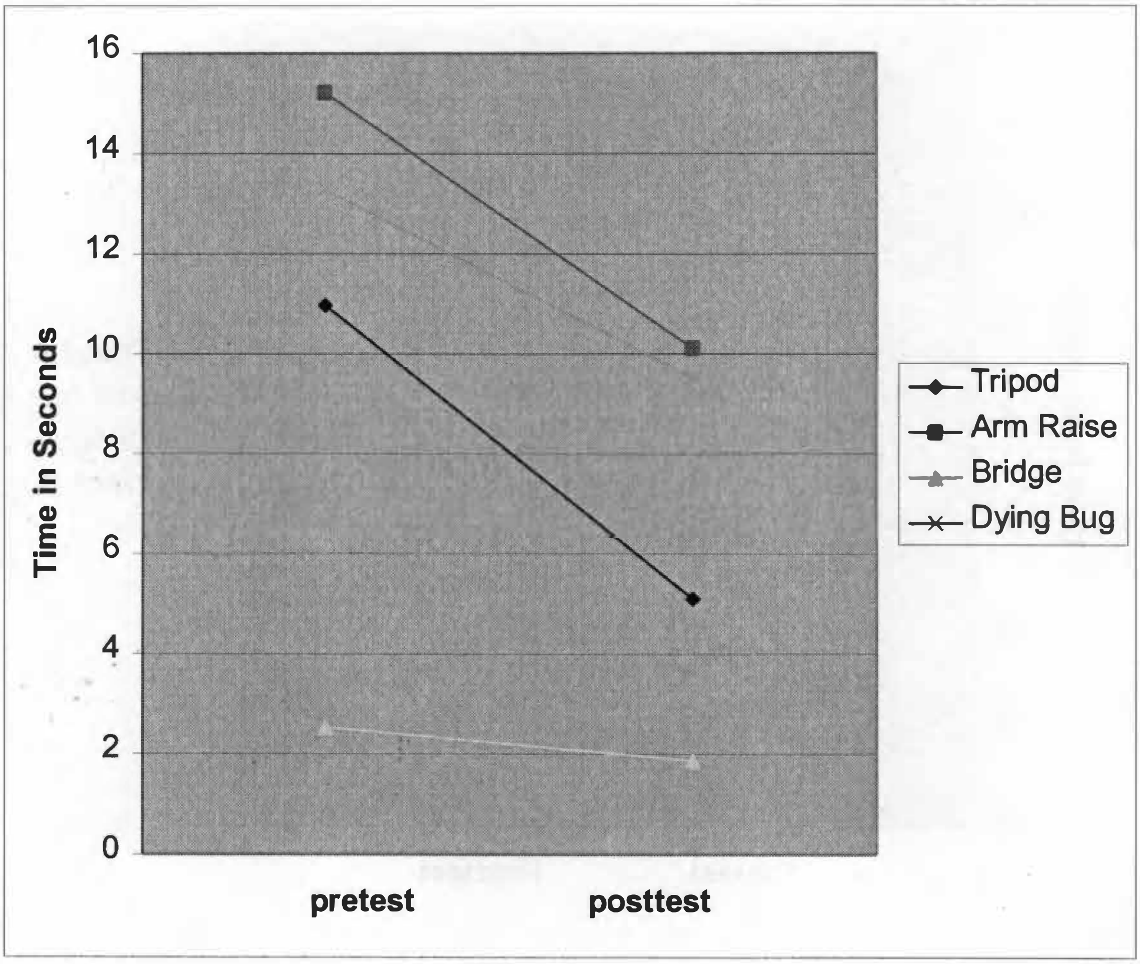

Figure A-4. Control Group, amount of time spent out of 10 deg arc.

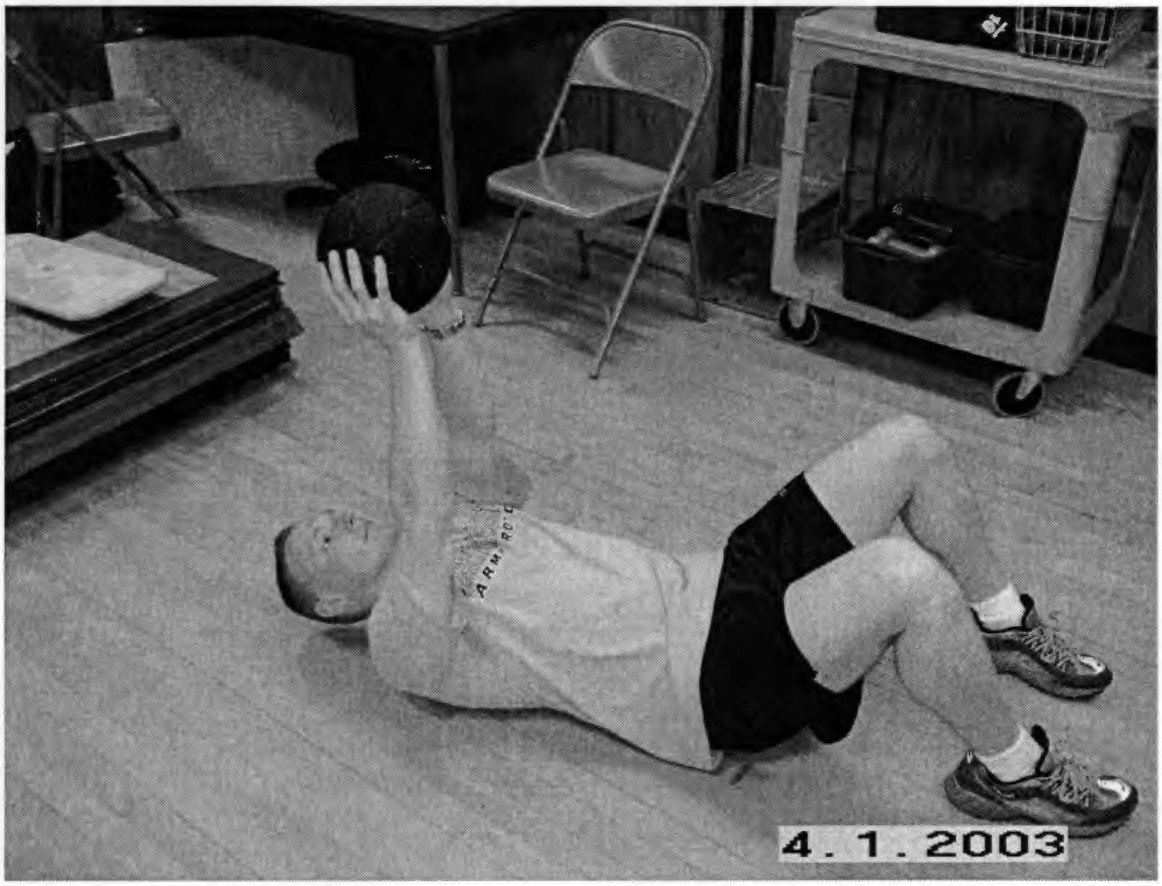

Figure A-5. Supine Torso Raise.

Figure A-6. Seated Torso Twist, Beginning.

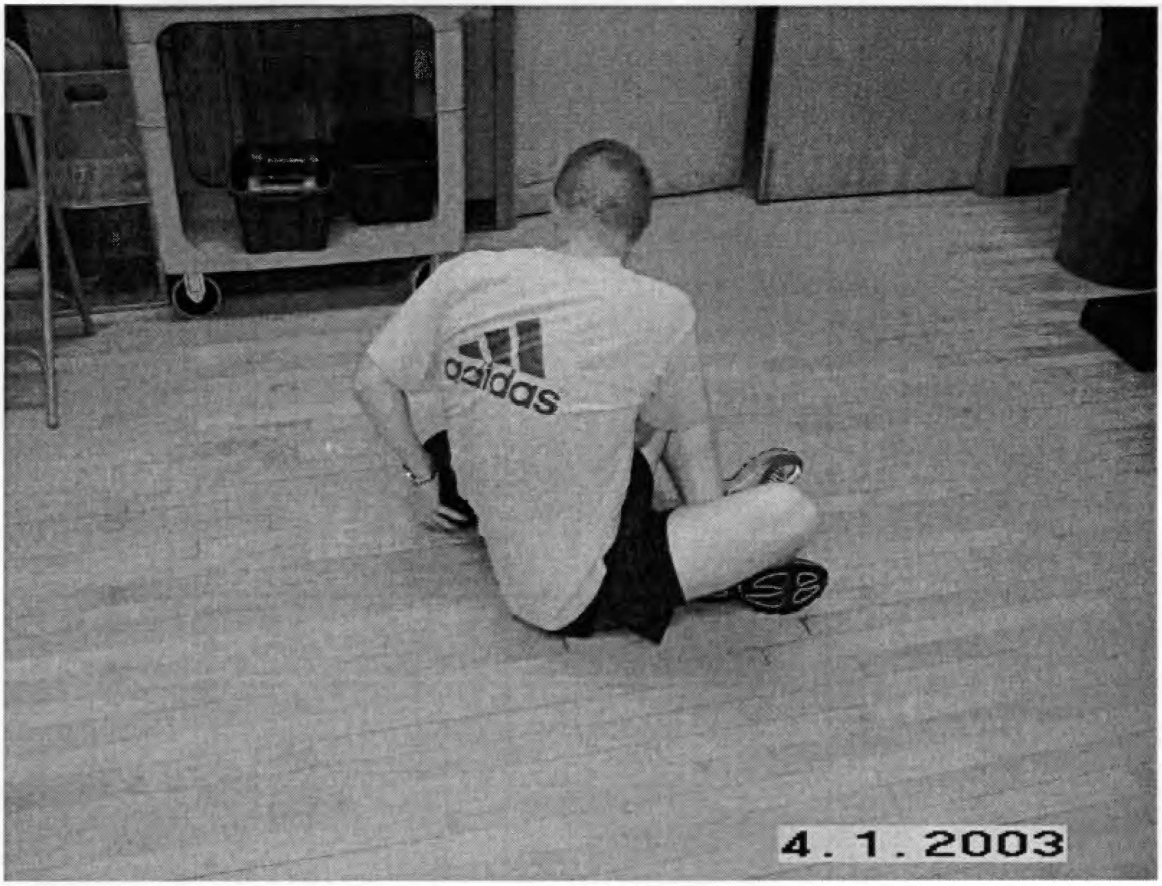

Figure A-7. Seated Torso Twist, Mid-Point.

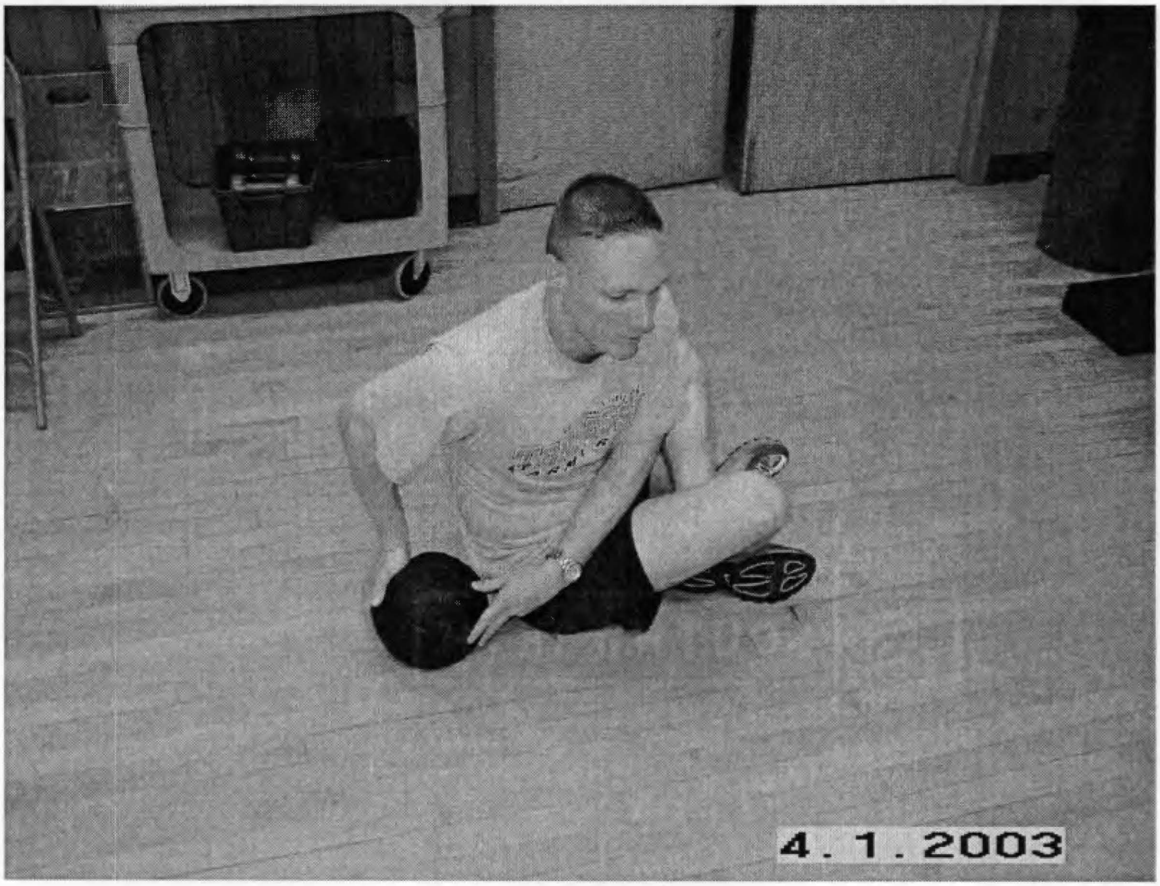

Figure A-8. Seated Torso Twist, Completion.

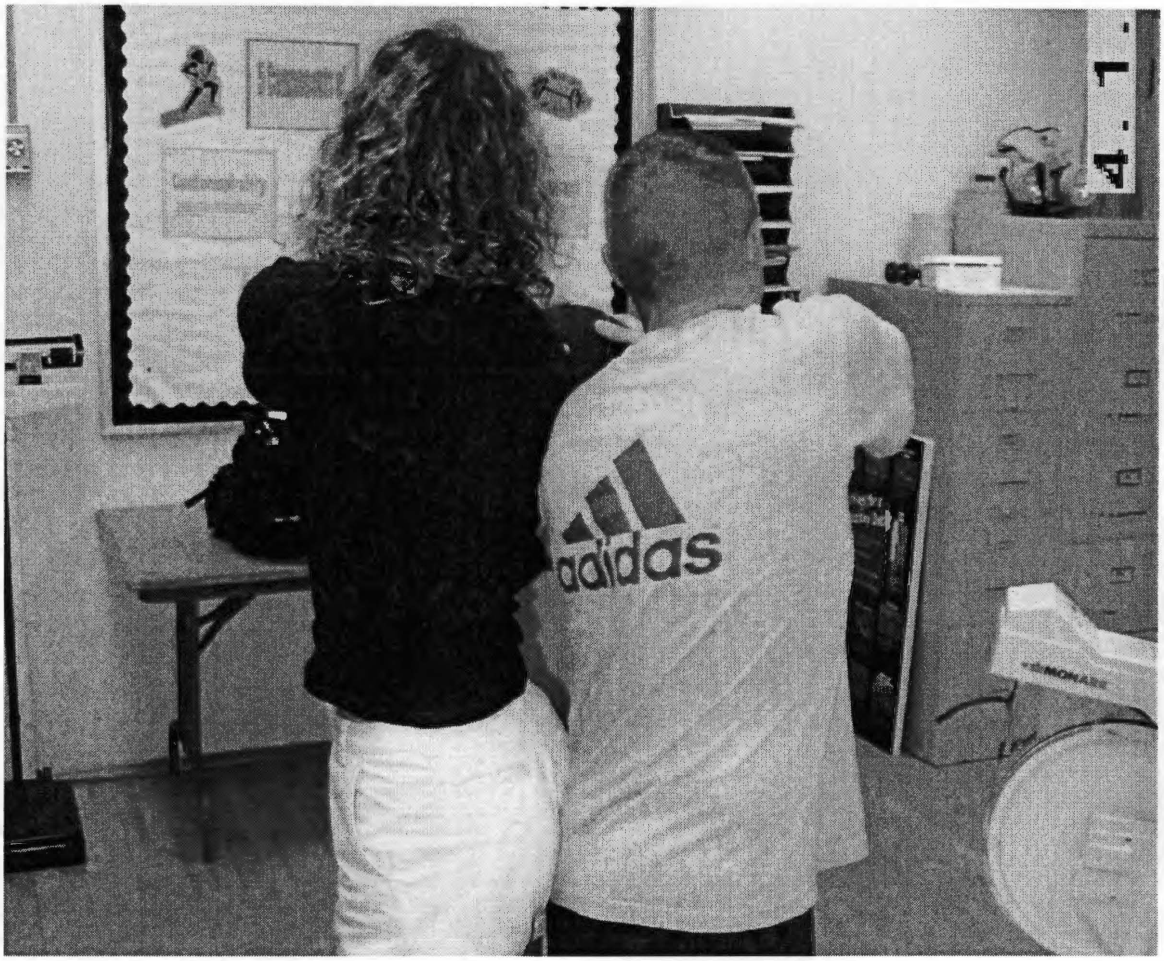

Figure A-9. Standing Torso Twist, Beginning.

Figure A-10. Standing Torso Twist, Completion.

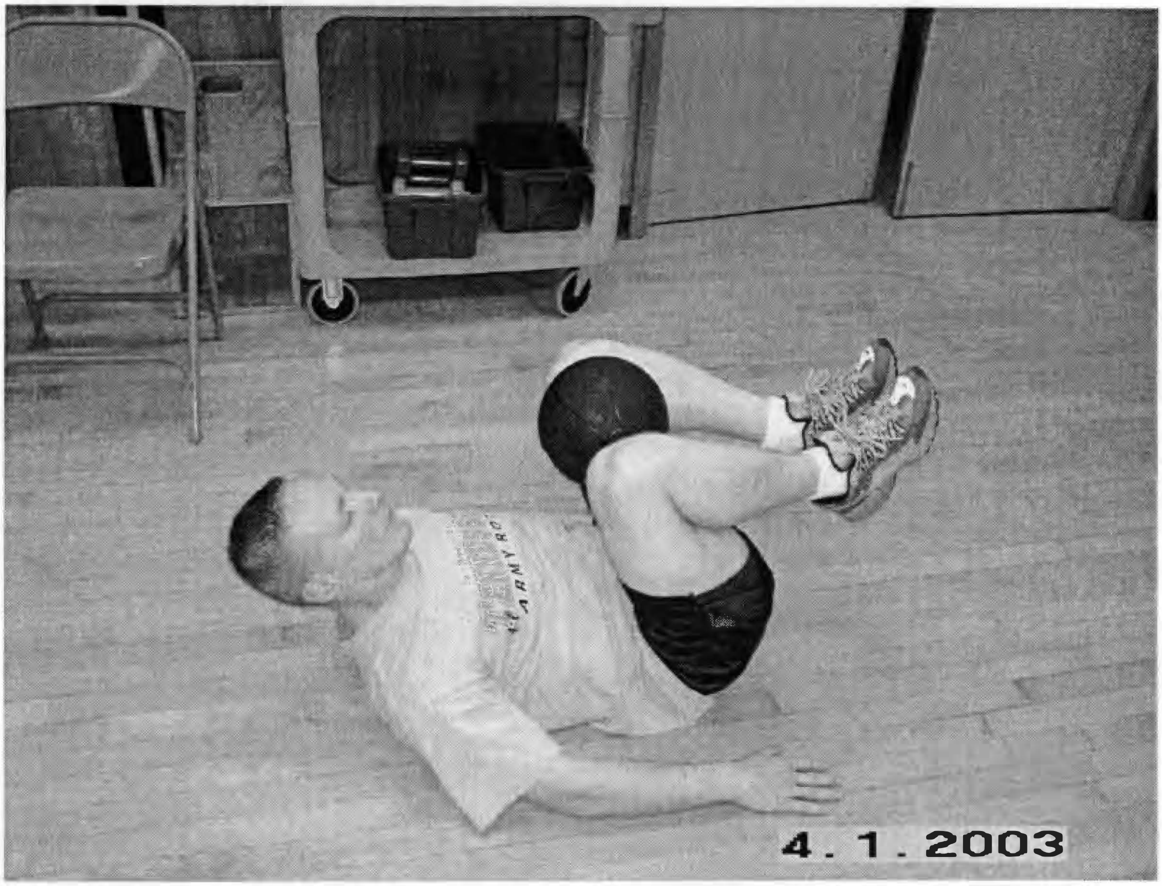

Figure A-11. Supine Leg Flexion, Beginning.

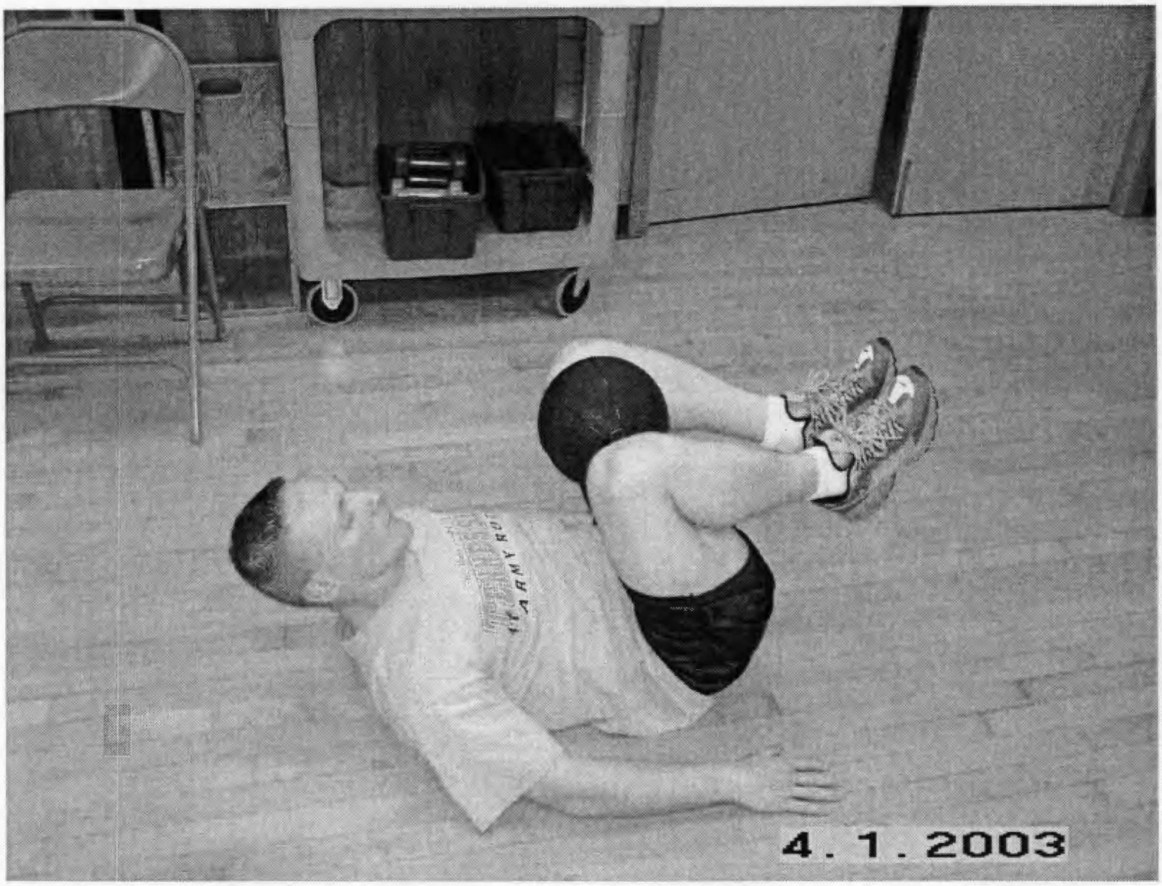

Figure A-12. Supine Leg Flexion, Mid-Point.

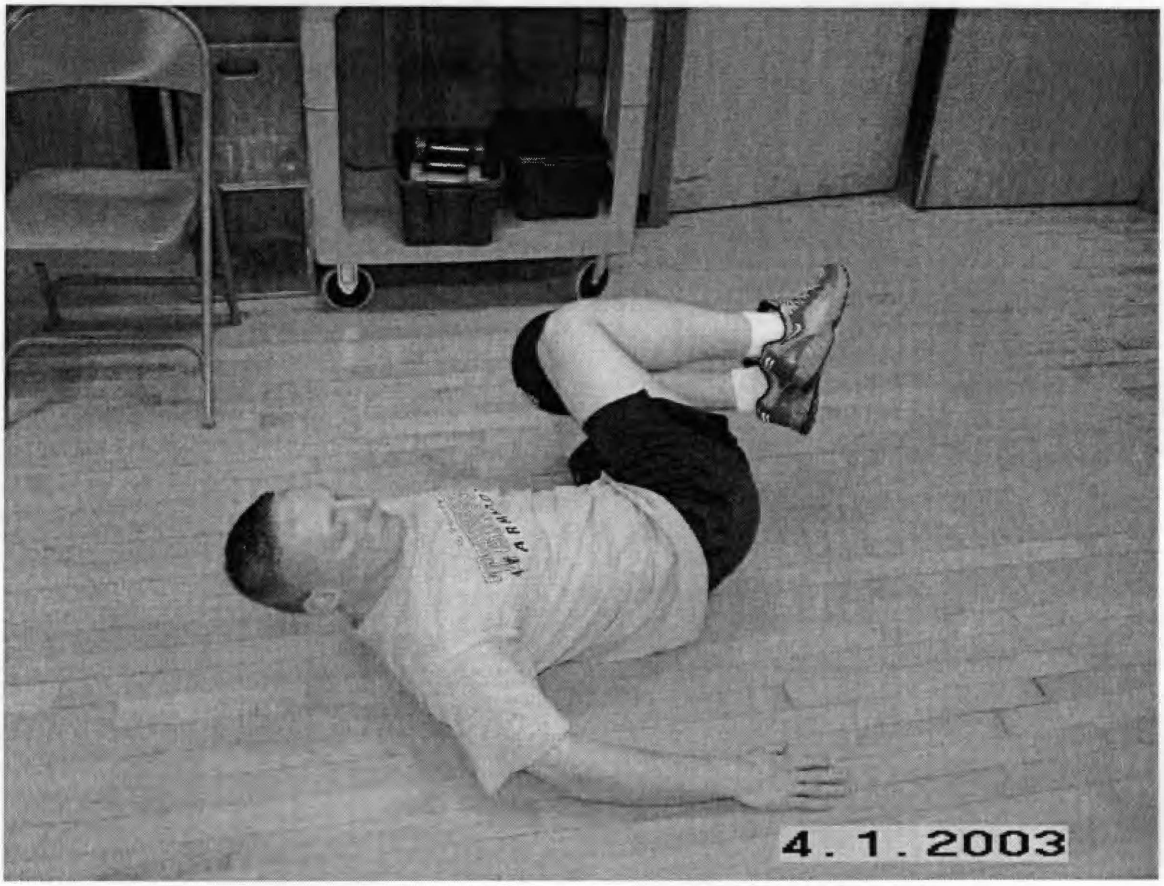

Figure A-13. Supine Leg Flexion, Completion.

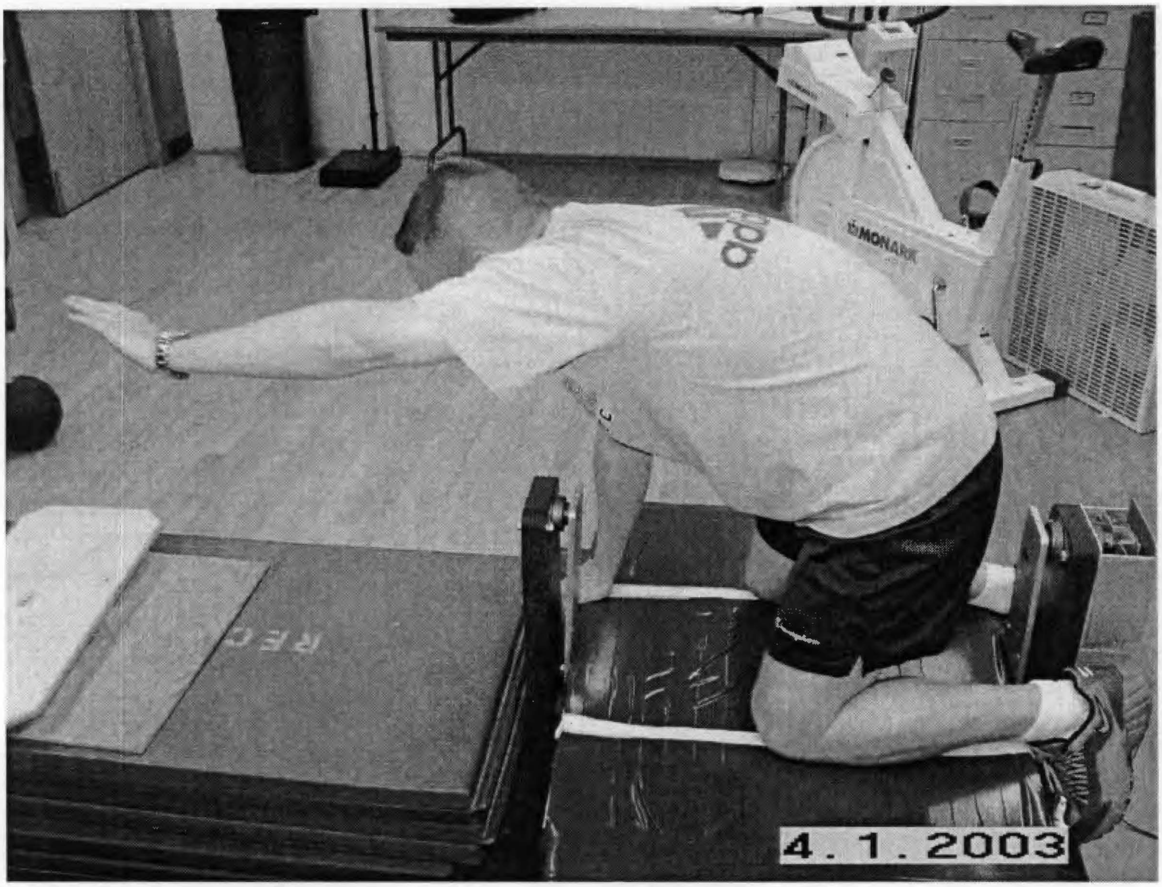

Figure A-14. Dynamic Quadruped

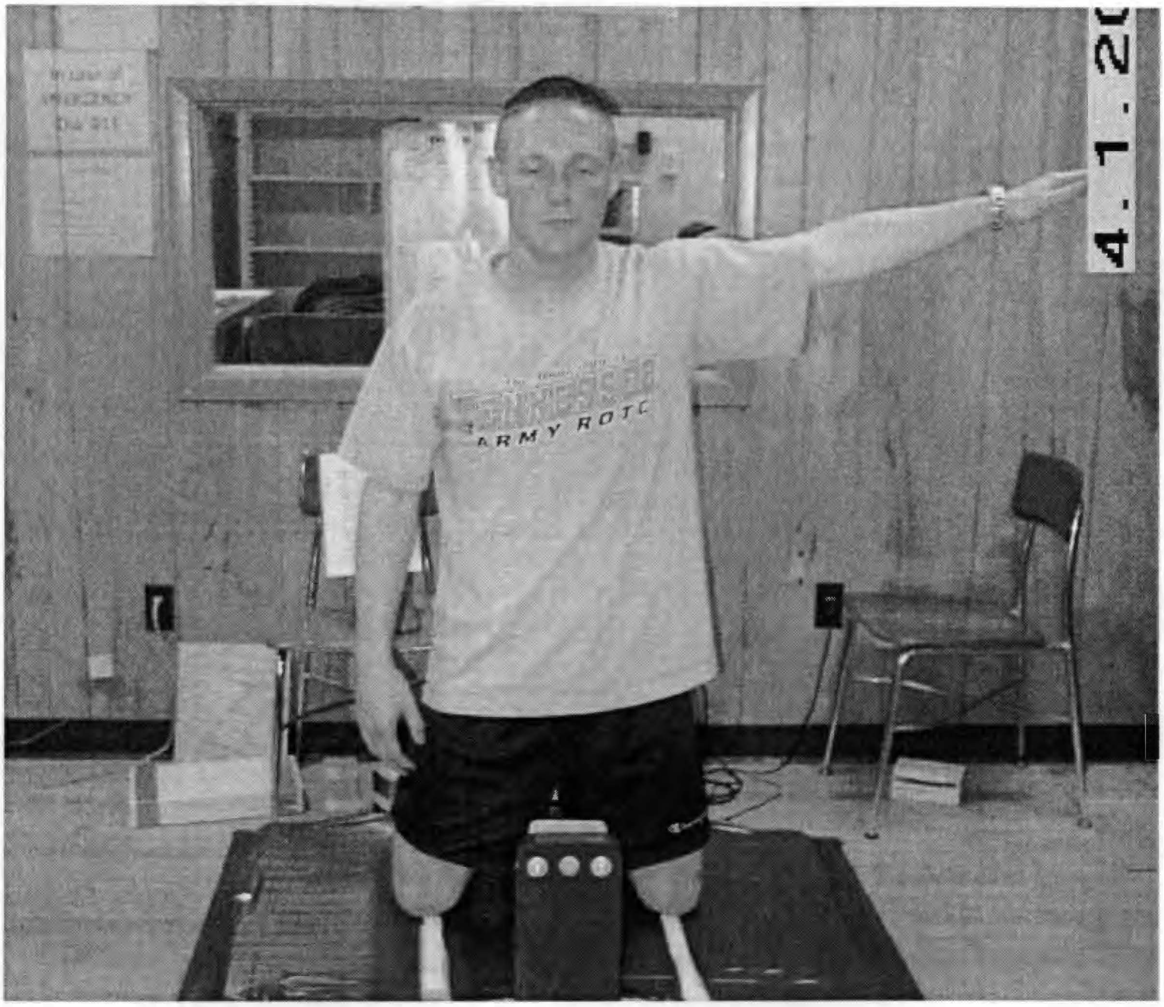

Figure A-15. Kneeling Arm Raise

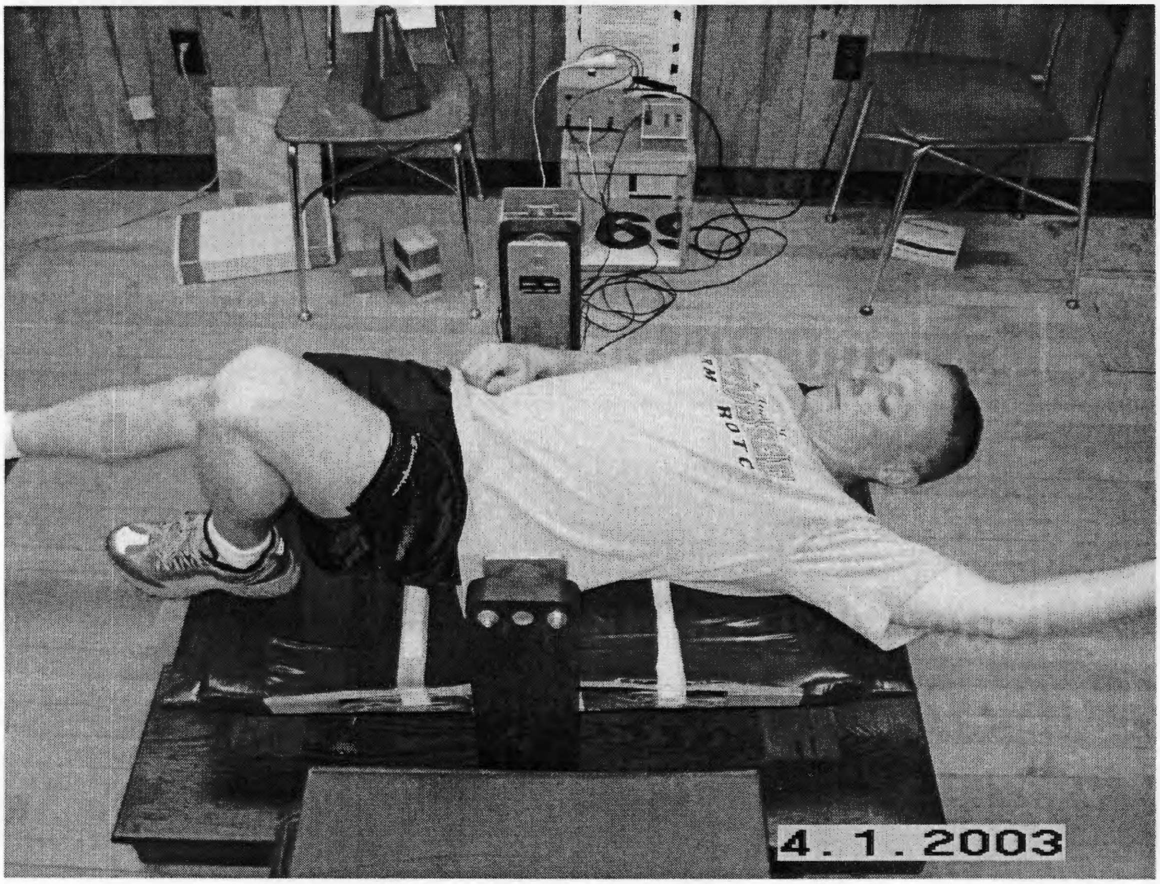

Figure A-16. Dying Bug

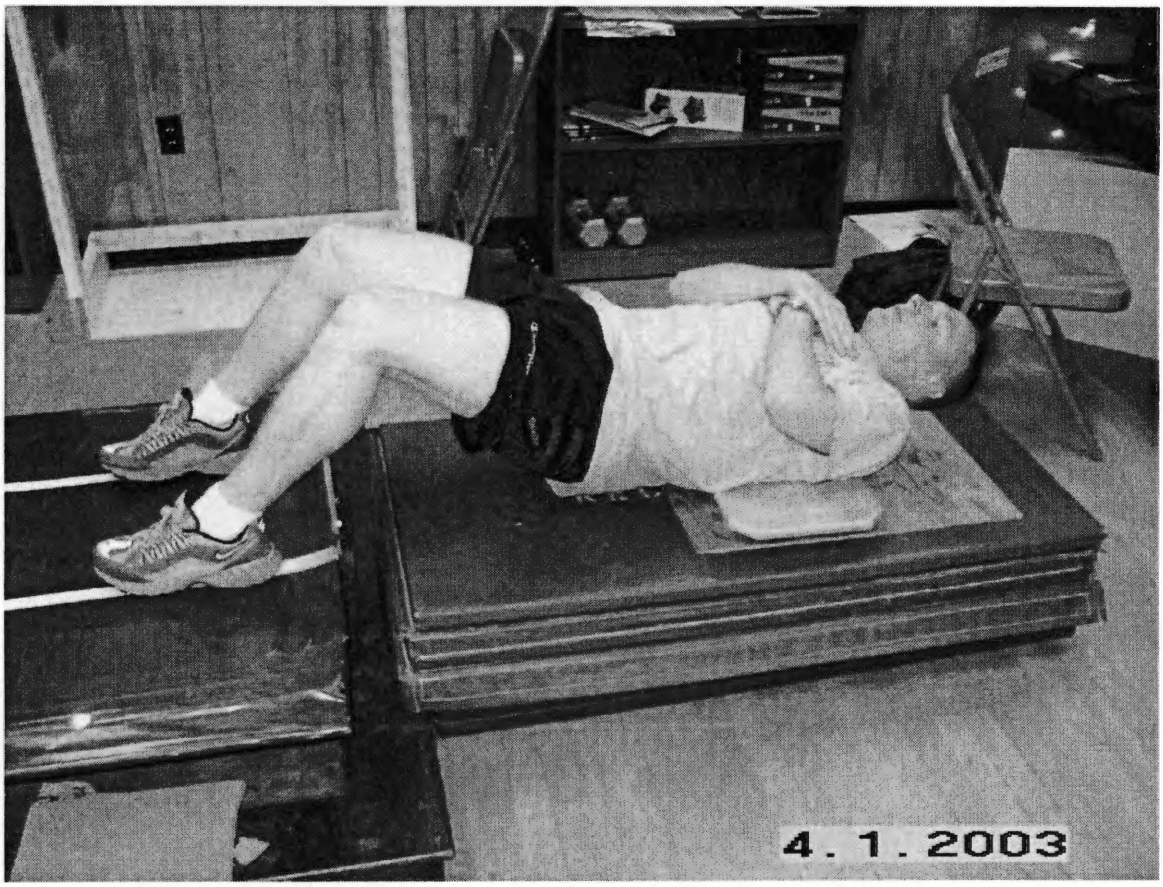

Figure A-17. Static Bridging

APPENDIX B- TABLES

Table B-1: Medicine Ball, number of times out of 10 deg arc, 1.

TEST		Mean	N	Std. Deviation	Std. Error Mean
Tripod	Tri-pre	10.61	12	3.668	1.059
	tr-post	4.78	12	4.001	1.155
Arm Raise	ar-pre	16.56	12	3.963	1.144
	ar-post	10.2222222	12	5.59461020	1.61502485
Bridge	br-pre	3.00	12	2.995	.865
	br-post	1.7222222	12	2.02924743	.58579327
Dying Bug	db-pre	9.6111111	12	3.48106954	1.00489822
	db-post	7.3611111	12	3.12519360	.90216568

Table B-2: Medicine Ball, number of times out of 10 deg arc, 2.

		N	Correlation	Sig.
Tripod	Tri-pre & tr-post	12	.521	.082
Arm Raise	ar-pre & ar-post	12	.601	.039
Bridge	br-pre & br-post	12	.470	.123
Dying Bug	db-pre & db-post	12	.641	.025

Table B-3: Medicine Ball, number of times out of 10 deg arc, 3.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
TEST					Lower	Upper			
Tripod	Tri-pre - tr-post	5.83	3.765	1.087	3.44	8.23	5.368	11	.000
Arm Raise	ar-pre - ar-post	6.3333333	4.51036965	1.30203156	3.4675812	9.1990855	4.864	11	.000
Bridge	br-pre - br-post	1.2777778	2.71484261	.78370755	-.4471509	3.0027065	1.630	11	.131
Dying Bug	db-pre - db-post	2.2500000	2.81814109	.81352726	.4594386	4.0405614	2.766	11	.018

Table B-4: Control Group, number of times out of 10 deg arc, 1.

TEST		Mean	N	Std. Deviation	Std. Error Mean
Tripod	Tri-pre	12.0000000	12	5.04124403	1.45528180
	tr-post	7.0833333	12	3.73118174	1.07709939
Arm Raise	ar-pre	15.9722222	12	4.09596582	1.18240349
	ar-post	11.92	12	6.575	1.898
Bridge	br-pre	1.53	12	1.527	.441
	br-post	1.8055556	12	2.38029933	.68713323
Dying Bug	db-pre	10.7777778	12	3.42106763	.98757716
	db-post	8.6666667	12	3.43481874	.99154676

Table B-5: Control Group, number of times out of 10 deg arc, 2.

TEST		N	Correlation	Sig.
Tripod	Tri-pre & tr-post	12	.633	.027
Arm Raise	ar-pre & ar-post	12	.897	.000
Bridge	br-pre & br-post	12	.084	.796
Dying Bug	db-pre & db-post	12	.698	.012

Table B-6: Control Group, number of times out of 10 deg arc, 3.

TEST		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Tripod	Tri-pre - tr-post	4.9166667	3.93924825	1.13716302	2.4137877	7.4195456	4.324	11	.001
Arm Raise	ar-pre - ar-post	4.0555556	3.42254360	.98800324	1.8809751	6.2301360	4.105	11	.002
Bridge	br-pre - br-post	-.2777778	2.71856072	.78478088	-2.0050689	1.4495133	-.354	11	.730
Dying Bug	db-pre - db-post	2.1111111	2.66414022	.76907104	.4183972	3.8038250	2.745	11	.019

Table B-7: Medicine Ball, amount of time spent out of 10 deg arc, 1.

TEST		Mean	N	Std. Deviation	Std. Error Mean
Tripod	Tri-pre	9.39967	12	4.391107	1.267603
	tr-post	3.0178611	12	3.23360272	.93346070
Arm Raise	ar-pre	13.8804444	12	4.65613272	1.34410974
	ar-post	6.59231	12	4.479752	1.293193
Bridge	br-pre	2.6019167	12	2.84822583	.82221198
	br-post	2.76725	12	4.121471	1.189766
Dying Bug	db-pre	10.60992	12	5.308150	1.532331
	db-post	6.5060556	12	3.02244856	.87250574

Table B-8: Medicine Ball, amount of time spent out of 10 deg arc, 2.

TEST		N	Correlation	Sig.
Tripod	Tri-pre & tr-post	12	.707	.010
Arm Raise	ar-pre & ar-post	12	.851	.000
Bridge	br-pre & br-post	12	.177	.583
Dying Bug	db-pre & db-post	12	.599	.039

Table B-9: Medicine Ball, amount of time spent out of 10 deg arc, 3.

		Paired Differences					t	df	Sig. (2-tailed)
TEST		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Tripod	Tri-pre - tr-post	6.3818056	3.10951913	.89764085	4.4061114	8.3574998	7.110	11	.000
Arm Raise	ar-pre - ar-post	7.2881389	2.50354645	.72271161	5.6974614	8.8788164	10.084	11	.000
Bridge	br-pre - br-post	-.1653333	4.57726322	1.32134208	-3.0735876	2.7429210	-.125	11	.903
Dying Bug	db-pre - db-post	4.1038611	4.25192856	1.22742605	1.4023146	6.8054076	3.343	11	.007

Table B-10: Control Group, amount of time spent out of 10 deg arc, 1.

TEST		Mean	N	Std. Deviation	Std. Error Mean
Tripod	Tri-pre	10.9688333	12	4.79047378	1.38289066
	tr-post	5.0943056	12	3.95750568	1.14243348
Arm Raise	ar-pre	15.2179722	12	5.27868032	1.52382375
	ar-post	10.1103611	12	7.49973580	2.16498724
Bridge	br-pre	2.5325833	12	4.68602610	1.35273921
	br-post	1.86944	12	2.959631	.854372
Dying Bug	db-pre	13.2830000	12	4.51535343	1.30347026
	db-post	9.5278333	12	6.23006845	1.79846585

Table B-11: Control Group, amount of time spent out of 10 deg arc, 2.

TEST		N	Correlation	Sig.
Tripod	Tri-pre & tr-post	12	.618	.032
Arm Raise	ar-pre & ar-post	12	.796	.002
Bridge	br-pre & br-post	12	-.154	.632
Dying Bug	db-pre & db-post	12	.132	.683

Table A-12: Control Group, amount of time spent out of 10 deg arc, 3.

		Paired Differences					t	df	Sig. (2-tailed)
TEST		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Tripod	Tri-pre - tr-post	5.8745278	3.89624880	1.12475015	3.3989694	8.3500862	5.223	11	.000
Arm Raise	ar-pre - ar-post	5.1076111	4.59123960	1.32537671	2.1904766	8.0247456	3.854	11	.003
Bridge	br-pre - br-post	.6631389	5.91565554	1.70770266	-3.0954893	4.4217671	.388	11	.705
Dying Bug	db-pre - db-post	3.7551667	7.19633968	2.07740433	-.8171694	8.3275028	1.808	11	.098

VITA

Gary L. Hall was born in Portsmouth, Virginia, 1963 to Jack and Mary Hall. As the son of a career Naval Officer, he lived in many places, to include Jonesborough, Tennessee after his father's retirement from the Navy. He graduated from David Crockett High School, Washington County, Tennessee in 1981. He attended East Tennessee State University, where he was active in the Army Reserve Officer Training Corps (ROTC), serving as Cadet Brigade Commander. After graduating in 1986 with a Bachelor of Science in Kinesiology and subsequently being commissioned an Army Second Lieutenant, he served at many duty locations and in many positions to include a general's aide-de-camp, service school instructor and a company commander. He earned a Masters of Physical Therapy from Baylor University in 1996, then practicing in several Army Physical Therapy clinics. He enrolled at the University of Tennessee in 2001 in order to pursue a Masters of Science, Biomechanics and Sports Medicine. The Masters degree was conferred May 2003.