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Isokinetic dynamometer versus a multi-axial stability platform in the proprioception and strength training of the peroneal muscle group

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Isokinetic dynamometer versus a multi-axial stability platform in the proprioception and strength training of the peroneal muscle group

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CHAPTER ONE

INTRODUCTION

Ankle injuries are the most common and frequent occurring injuries in sports today (Feuerbach, Grabiner & Koh, 1994). Ankle sprains usually occur in athletes that are participating in running or jumping activities. Injuries to the ankle joint represent about 20% of all sports related injuries, and 15% of all time lost injuries (Payne, Berg, & Latin, 1997). The majority of the sprains to the ankle occur to the lateral ligamentous structures due to the forcefully plantar flexion and inversion of the talocrural joint. This inversion mechanism accounts for 85% of all ankle sprains (Kinzey, Ingersoll, & Knight, 1997). Often after an initial ankle sprain, athletes report feeling as if their ankle is unstable. This "feeling" is due to the decrease in proprioception and peroneal muscle strength (Bernier, Perrin, & Rijke, 1997). The loss of proprioception is proportional to the amount of ligament damage to the joint (Glencross & Thornton, 1981).

There are basic components that must be considered in the short-term goals of all rehabilitation programs. These components include reducing of pain, restoration of full range of motion, restoration or increase in muscular strength, reestablishing neuromuscular control, improving balance, and incorporating appropriate functional progression (Prentice, 1999). Konradsen et al (1998) reports that the main contributions to recurrent ankle instability are lack of proprioception and muscular strength. Recent technologies have allowed athletic trainers, physical therapists, and physicians more tools to help athletes regain their lost strength and proprioception. The use of a multi-axial unstable balance system is especially effective in regaining proprioception after an acute ankle injury (Prentice, 1999). Isokinetic strengthening is also a factor considered in evaluation and rehabilitation of acute ankle sprains (Davies, 1992).

Previous research has provided therapists with norms for balance indexes and peak torque production at various speeds (Davies, 1992). These norms allow therapist to evaluate the status of their patients, and determine appropriate return to play criteria. The problem with both of these methods of rehabilitation is that each system only addresses either proprioception or strength, but not both of the crucial factors need for complete recovery. With time often being a factor in return to play criteria, a method of rehabilitating both strength and proprioception would be greatly beneficial to therapists and the patients that they treat.

Purpose of the Study

The purpose of this study was to determine the most efficient method for increasing proprioception and strength in the peroneal muscle group.

Null Hypotheses

This study tested the following null hypotheses:

1. There will be no significant difference between means for balance stability index of the peroneal muscle group following proprioceptive training.

2. There will be no significant difference between means for peak torque to body weight ratio of the peroneal muscle group following proprioceptive training.

3. There will be no significant difference between means for balance stability index of the peroneal muscle group following isokinetic strengthening.

4. There will be no significant difference between means for peak torque to body weight ratio of the peroneal muscle group following isokinetic strengthening.

5. There will be no significant difference between means for balance stability index of the peroneal muscle group following the peroneal challenge test.

6. There will be no significant difference between means for peak torque to body weight ratio of the peroneal muscle group following the peroneal challenge test.

Definitions

The following contains definitions that operationalize the variables that were used in this study as well as specialized terminology specific to isokinetic and proprioceptive rehabilitation of the peroneal muscles:

Isokinetic Exercise: A form of exercise in a fixed speed with accommodating resistance throughout the active range of motion.

Peak Torque to Body Weight: A ratio displayed a percentage of the maximum torque production to the subjects body weight.

Propriception: A sensation relating to the body's movement and position resulting from stimuli received by sense organs located in muscles, tendons, joints and the inner ear.

Stability Index: Represents the variance of platform displacement in degrees from levels of motion in the frontal and sagittal planes.

Basic Assumptions

1. That all subjects that were involved in the study had the same desire to participate in the research project.
2. That all subjects gave their maximal effort into the testing procedures involved in the study.
3. That the researchers were consistent in subject placement on the testing devices and direction of their tasks.
4. That all of the testing apparatuses were properly calibrated before testing procedures were performed.

Limitations of the Study

1. This study was only intended to measure proprioception and strength changes following two weeks of treatment sessions.
2. Hip internal and external rotation was not completely eliminated during eversion and inversion isokinetic strength testing of the peroneal muscle group.
3. The population of this study was not intended to represent injured athletes.

Chapter Two

REVIEW OF LITERATURE

Ankle sprains have always been the most common orthopedic injury in running and jumping sports (Konradsen, Olesen, & Hansen, 1998). The inversion ankle sprain is the dominant ankle injury accounting for about 85% of all ankle sprains (Kinzey, Ingersoll, & Knight, 1997). These inversion sprains usually occur when the athlete's foot becomes forced into inversion while the foot is plantar flexed. This mechanism of injury occurs due to lack of bony stability and due to lack of peroneal strength (Arnheim & Prentice, 1999). Bernier et al (1997) stated that the peroneal muscles, or everting muscles, resist inversion forces, until they are no longer strong enough, and then ligamentous damage occurs. Inversion sprains result in loss of function, strength, and proprioception (Bernier, Perrin, & Rijke, 1997).

Anatomy of the Ankle

The ankle joint, also called the talocrural joint, is a hinge joint that is formed by the medial and lateral malleolus that articulate with the trochlea of the talus, as well as the articulate surface of the distal tibia (Arnheim & Prentice, 1999). An articular capsule and several ligaments, which help to fortify the talocrural joint, support the ankle joint. There are three lateral ligaments, anteriotalofibular, posterior talofibular, and calcaneofibular ligaments, which maintain articulation of the ankle. These ligaments also help prevent excess inversion of the ankle (Hamill & Knutzen, 1995). Hollis et al (1995) reported the posterior talofibular ligament is the strongest of the lateral ligaments followed by the calcaneofibular ligament. Hollis also reported that the anteriotalofibular is the weakest of the ligaments. The deltoid ligament structure supports the talocrural joint on the medial aspect (Hollis, Blasier, & Flahiff, 1995). The deltoid is a very strong structure due to the anterior and posterior tibiotalar ligaments, the tibiocalcaneal and the tibionavicular ligaments (Hollis, Blasier, & Flahiff, 1995).

The major musculature of the ankle that helps to prevent inversion ankle sprains is the peroneal muscle group (Konradsen, Olesen, & Hansen, 1998). The peroneal group, the primary everters of the ankle, is comprised of the peroneus longus, peroneus brevis, and the peroneus tertius muscles. The peroneal muscles originate from the proximal fibula. The peroneus brevis and tertius insert onto the base of the fifth metatarsal, while the peroneus longus has it's insertion on the undersurface of the medial cuneiforms and first metatarsal bones (Thompson & Floyd, 1998). The peroneus tertius in innervated by the deep peroneal nerve, while the superficial peroneal nerve innervates both the peroneus brevis and longus (Tortora & Grabowski, 1996). The peroneus longus and brevis tendons are contained by a common synovial sheath within a fibroosseous tunnel on the posterior aspect of the distal fibula (Mason & Henderson, 1996). Inversion of the talocrural joint is primarily performed by the tibialis posterior and flexor digitorum longus (Tortora & Grabowski, 1996). They are both innervated by the tibial nerve and pass posterior to the medial malleolus, inserting onto the metatarsals and phalanges respectively (Bernier, Perrin, & Rijke, 1997).

The main plantar flexors of the ankle consist of the gastrocnemius, soleus, plantaris, and the peroneus longus and brevis (Tortora & Grabowski, 1996). The gastrocnemius, soleus, and plantaris are all innervated by the tibial nerve, and have a common insertion onto the calcaneus by way of the Achilles tendon (Tortora & Grabowski, 1996). Tortora et al (1996) reports that dorsiflexion of the ankle in achieved mainly by the tibialis anterior, which is innervated by the deep peroneal nerve. Tortora goes on to state that the tibialis anterior originates from the lateral anterior tibia and shares an insertion with the peroneus longus.

Biomechanics of the Ankle

Bernier et al (1997) reported that stability of the ankle depends on the orientation of the ligaments, the types of loading, and the position of the ankle at the time of stress. The axis of rotation for the ankle joint is an line between the two malleoli, running oblique to the tibia and not in line with the body (Hamill & Knutzen, 1995). Kaminski et al (1999) states the lateral malleolus is slightly longer than the medial, which produces a lever that allows the talocrural joint to move into inversion more easily. The talocrural joint is in the strongest position during maximum eversion and dorsiflexion, and is the weakest during maximum plantar flexion and inversion (Hamill & Knutzen, 1995).

Proprioception of the Ankle

Proprioception is an important factor in rehabilitation and returning to play after an inversion ankle sprain. The term proprioception originated in 1906 to best describe the sensorimotor system (Sherrington, 1906). Sir Charles Sherrington stated that conscious muscle sensation, postural equilibrium, and segmental joint stability all contribute afferent information to the proprioceptors (Sherrington, 1906). Proprioceptors refer to those receptors located in joints, muscles, and tendons that were adapted for excitation with constant changes going on in the organism itself (Sherrington, 1906). There are two traditional mechanisms associated with proprioception, feedback and feed-forward (Lephart & Fu, 2000). Lephart et al (2000) reported that the feedback mechanism is a reactive process at the spinal reflex level in response to excess joint loads, which provides conscious appreciation of position and motion that can be used for fine tuning motor commands for precision movement.

There is an electromechanical time delay associated with the feedback loop, which affects the reaction process in providing joint stabilization and protection (Lephart, 2000). This information would suggest that the feedback mechanism is best suited for maintaining posture and regulating slow movements. Lephart et al (2000) stated that the feed-forward mechanism implies that proprioception is used in anticipation of loads or activities that will occur. The model suggests that the brain uses previously acquired sensations from previous exposures to prepare a response to a known condition. This information is programmed into ongoing proprioceptive information to prevent injury from occurring (Lephart, 2000). The two systems work in conjunction with one another to contribute to motor activation, which results in coordinated motor skills and dynamic joint stabilization (Lephart, 2000).

These two processes are best described through alpha-gamma co-activation. Alpha motor neurons innervate regular skeletal muscle fibers, while the gamma motor neurons are smaller diameter motor neurons that stimulate contraction of muscle spindles (Tortora & Grabowski, 1996). Both motor neurons originate from the anterior gray horn of the spinal cord (Tortora & Grabowski, 1996).

Lephart et al (2000) state that alpha-gamma co-activation increases the sensitivity of muscle spindles to stretch, which heightens the joints awareness of motion and position. The heightened sensitivity of muscle spindles evokes an increased stretch reflex, which becomes added onto descending motor commands. Sensory information is then sent to skeletal muscle fibers to preprogram future muscle activation strategies. Lephart also reported that these preactivated muscles are stiffer and recognize unexpected joint loads more quickly. Lephart went on to report that a stiffer muscle decreases electromechanical delay and effectively facilitates feedback neuromuscular control mechanisms.

Proprioception with Ankle Injury

Joint proprioceptors are believed to receive damage during injury to the lateral ligaments of the ankle, due to fact that joint receptor fibers posses less tensile strength that the associated ligamentous fibers (Freeman, Dean, & Hanham, 1965). Damage to joint receptor fibers is believed to decrease afferent nervous transmission, therefore decreasing the supply of communication from the injured joint to the brain (Lephart, 2000). This decreased communication causes a disruption in proprioceptive function, which produces a reduction in peroneal muscle reaction time due to a sudden inversion mechanism (Konradsen, Olesen, & Hansen, 1998). Most athletes that have had an inversion ankle sprain also have accompanying mechanical instability. Approximately 50% of those athletes with mechanical instability will present with a decrease in proprioception of the ankle (Konradsen, Olesen, & Hansen, 1998). Prentice (1999) reports an 83% reduction in ankle proprioception following inversion ankle injures. Lephart et al (1997) states that chronic ankle instability resulted in a prolonged peroneal reaction time in response to sudden inversion stresses. Lephart went on to report that training the ankle to react to a sudden inversion mechanism will cause the peroneal muscle group to react faster, helping to prevent further damage (Lephart, Pincivero, & Fu, 1997).

Therapeutic interventions such as orthotics, taping, and rehabilitation have been shown to improve proprioceptive control in athletes with acute ankle instability (Guskiewicz & Perrin, 1996). There are some methods of interventions that statistically show improvements in ankle proprioception, while others show questionable effects. Kinzey et al (1997) suggested that wearing a prophylactic ankle brace or taping after initial injury would help to increase an athlete's proprioception. Kinzey's results show that not only does a brace or tape not increase one's proprioception, but further hinders it by producing a false feeling a falling forward due to the excessive eversion and dorsiflexion placed upon the ankle. Grabiner et al (1994) states that brace application increases afferent feedback to receptors, which leads to an improved ankle joint position sense. Karlsson et al (1992) reports that the application of tape increases peroneal reaction time by fifteen percent in a chronically sprained ankle.

The use of orthotics may restrict undesirable motion of the foot and ankle and thus enhance joint mechanoreceptors and provide structural support for detecting and controlling postural sway in ankle injured athletes (Guskiewicz & Perrin, 1996). Lephart et al (2000) reported a decrease in functional instability following ankle sprain when coordinated exercises were preformed during rehabilitation. By placing the ankle in an unstable position, therapists can trigger the protective spinal reflexes to help produce joint stability (Laskowski, Newcomer-Aney, & Smith, 1997).

When considering proprioceptive training, there is a progression of methods of treatment. Individuals should begin with open-chain activities, so as not to aggravate to injured ankle (Hanney, 2000) Hanney also reports that after open chain exercises, patients should progress to partial weight-bearing exercise, such as using parallel bars or a pool. Hanney went on to state that there should be a progression to full weight bearing, closed chain exercises. These exercises include trampoline balance with ball toss, single leg hopping, and computerized force plates. There are a variety of force plates and computerized multi-directional platforms that are available to therapist to assess and treat proprioception deficits. The most effective method of this is through Sensory Organization Testing (Nashner, 1993). Sensory Organization Testing incorporates foam and hard surfaces, eyes open and closed with direction sway to assess postural sway (Nashner, 1993). The most efficient, and cost effective method of triggering spinal reflexes is by using a computerized multi-directional platform to train the proprioceptors and everters of the ankle to respond quicker to an inversion mechanism (Prentice, 1999). A computerized multi-directional platform offers a 20 degrees of deflection in any direction. These degrees of deflection are sufficient to stress joint mechanoreceptors that provide proprioceptive feedback (Prentice, 1999). Multi-directional platforms are an important component is regaining function joint proprioception (Laskowski, Newcomer-Aney, & Smith, 1997).

When evaluating multi-directional platform patient data, there are two main components that make up the overall balance index, anterior/posterior stability and medial/lateral stability (Biodex, 1999). These components represent the variance of the platform displacement in degrees from level of motion in the sagittal and frontal plane, respectively (Biodex, 1999). When reviewing a patient's stability index, a high number is indicative of large deviations during the test. Laskowski et al (1997) reports that when using a wobble board in the treatment of ankle proprioception, it should take approximately eight weeks of treatment to obtain maximum dynamic ankle. Clinicians considering balance exercises should base their rehabilitation on a time-based protocol. The athlete should initially perform 10 trials at 15-second periods, and continue to progress to 30-second periods later in the rehabilitation period (Prentice, 1999). Hanney (2000) also reports that proprioceptive training should be performed for at least 30-seconds, and for a minimum of five repetitions.

Eversion Strengthening of the Ankle

The peroneal muscle group controls eversion of the talocrural joint. These muscles react to an inversion mechanism by eccentrically contracting to prevent the talocrural joint from proceeding into further inversion, causing ligamentous damage (Bernier, Perrin, & Rijke, 1997). By training the peroneal muscle group to contract eccentrically during inversion mechanism, athletes can reduced the change of a possible inversion ankle sprain (Payne, Berg & Latin, 1997). Payne et al (1997) reported that inversion sprains result in loss of strength, flexibility and proprioception of the talocrural joint Konradsen et al, 1998, reported a 13% decrease in eccentric peroneal muscle strength after an initial inversion ankle sprain. Konradsen went on to report that mechanical instability was seen in about 50% of acute ankle sprains. Other research suggests that there is no significant relationship between ankle sprains and loss of concentric or eccentric peroneal strength (Bernier, Perrin, & Rijke, 1997).

The most effective method for determining appropriate loss of muscular strength following ankle sprains is through the use of isokinetic testing (Kaminski, Perrin, & Gansneder, 1999). These devices enable both clinicians and researchers to quantify concentric, eccentric, and isometric force production about a body joint. Isokinetic testing of the ankle joint is an objective method of determining muscle function prior to initiation of stressful activity (Davies, 1992).

When developing isokinetic protocols, there are specific speeds that have normative data to help clinicians effectively evaluate deficits of the talocrural joint. Davies (1992) reported that to evaluate power clinicians should use speeds of 30^0/second and 60^0/ second. Davies went on to state a speed of 120^0/second is appropriate for determining endurance of the peroneal muscles. Kaminski et al (1998) reported that the addition of 150^0/second and 180^0/ second should be included when testing the peroneal muscles for endurance. Davies (1992) stated that when conducting isokinetic testing, there is set standard for the number of repetitions to be performed during testing. Davies went on to report that the important concept is that clinicians show make sure that repetitions performed should be consistent during both pre and post testing.

Most inversion ankle sprains result in loss of function, strength, and proprioception. Due to this, peroneal muscle proprioception and strengthening are important aspects of inversion ankle sprain rehabilitation. Research describes several current methods for cliniciar to base their treatment protocols for rehabilitation of the peroneal muscle group. Providing a quality method for treating both of these components of peroneal muscle injury is a growing concern that needs to be addressed.

Chapter Three

METHODOLOGY

Therapists continue to try new rehabilitation methods in the treatment of ankle injuries. Isokinetic dynamometers and multi axial stability systems are two of the more recent technologies that are available for this use. Both methods provide feedback on the patient's levels of strength and balance. Both of these systems need to be evaluated to determine their effectiveness at treating both strength and proprioception of the ankle.

Subjects

Four male and six female (age = 27.10 ± 4.33yr) volunteered as subjects for this study. All subjects were obtained from the staff population at Healthsouth Western Hills Rehabilitation Hospital in Parkersburg, West Virginia. Subjects were informed of the procedures and signed a consent form before participation (Appendix D). Each subject was asked to fill out a previous medical history for any lower extremity injuries during the past five years. Seven subjects had incurred no ankle or knee trauma within the last five years. One subject reported a right ankle sprain three-years prior and one subject reported a right ankle dislocation three years prior.

Another subject reported treatment of compartment syndrome one-year prior.

Instrumentation

The instruments used during this study were a Biodex Stability System Multi-axial Platform (Biodex Medical Systems, Shirley, NY) and a Biodex System II Dynamometer (Biodex Medical Systems, Shirley, NY). Validity and reliability statistics for the Biodex Stability System Multi-axial Platform were reported by Finn et al (1999). Brown et al (1993) reported validity and reliability statistics for the Biodex System II Dynamometer. Each system was properly calibrated prior to data collection.

Procedures

Each subject began by performing a pre-treatment balance test on the Biodex Stability System (Biodex Medical Systems, Shirley, NY). Subjects were asked to remove their shoes and step up onto the platform, centering their right foot in the middle of the platform. The coordinates for the center of their right heel and angle of the great toe were then entered into the stability system. Subjects were asked to cross their arms across their chest while they were being tested. Next, they performed a 1-minute practice session, followed by a balance test consisting of three 30-

second trials. Subjects were given a 5-minute rest period after the balance testing, before their isokinetic test was performed.

Subjects were then placed onto the Biodex System II Dynamometer (Biodex Medical Systems, Shirley, NY). For the testing procedure the power head of the dynamometer was rotated to 60^0 and the inversion/eversion apparatus was attached. Each subject's right hip was placed into 130^0 of flexion and their knee was placed into 35^0 of flexion (Figure 1, Appendix A). This positioning was used in an attempt to minimize the amount of hip rotation during the procedure. Subjects were secured onto the seat using a thigh, waist, and chest belts (Figure 2, Appendix A). Each subject's right ankle was secured into the inversion/eversion apparatus with one metatarsal strap and one talocrural strap. Right ankle range of motion was limited to 10^0 of inversion and 10^0 of eversion. Each subject was asked to complete 15 repetitions at 30^0/sec and then 15 repetitions at 60^0/sec. Subject were randomly placed into three different treatment groups prior to the pre-treatment testing. One group was asked to perform isokinetic eversion and inversion strengthening on the Biodex System II Dynamometer. This strengthening consisted of two 15-repetitions sets at 30^0/sec and two 15-repetitions sets at 60^0/sec. Subjects were asked to perform this treatment three times per week for two weeks. The second group, which we used as the control group, was asked to perform five 1-minute ankle proprioception treatments three times a week for two weeks, on the Biodex Stability System.

The third group was instructed to perform five 1-minute peroneal challenges on the Biodex Stability System, three times a week for two weeks. This challenge was performed with the addition of a 2x4 board attached to the platform. The board was placed along the centerline of the platform in order to ensure proper foot placement (Figure 3, Appendix A). The block was added in an order to isolate the peroneal muscle group. Subjects were asked to place the medial aspect of their foot onto the board. The shaft of the third metatarsal and the center of the heel were used as landmarks for the foot placement (Figure 4, Appendix A). Following two weeks of treatment, subjects were re-tested on both the Biodex System II Dynamometer and the Biodex Stability System using the same procedures performed during the pre-treatment testing session.

Chapter Four

RESULTS

The following null hypotheses were tested is this study with the results as stated:

1. *There will be no significant difference between means for balance stability index of the peroneal muscle group following proprioceptive training.*

The null hypothesis was accepted because the data failed to meet a .05 level of significance using a pair samples t-test (Table 1, Appendix B). Subjects displayed a mean of a 12% drop in total balance index score following six treatment sessions (Figure 1, Appendix C).

2. *There will be no significant difference between means for peak torque to body weight ratio of the peroneal muscle group following proprioceptive training.*

The null hypothesis was accepted because the data failed to meet a .05 level of significance using a pair samples t-test (Table 2, Appendix B). The mean peak torque to body weight ratio was increased by 3% during the two week treatment period (Figure 1, Appendix C).

3. *There will be no significant difference between means for balance stability index of the peroneal muscle group following isokinetic strengthening.*

The null hypothesis was accepted because the data failed to meet a .05 level of significance using a pair samples t-test (Table 3, Appendix B). After six-treatment session, the subject's mean balance index decreased by 6% (Figure 2, Appendix C).

4. *There will be no significant relationship between peak torque to body weight ratio of the peroneal muscle group and isokinetic strengthening.*

The null hypothesis was rejected because the data meet a .05 level of significance using a pair samples t-test (Table 4, Appendix B). Subjects displayed a mean increase of 14% following a two-week treatment period (Figure 2, Appendix C).

5. *There will be no significant difference between means for balance stability index of the peroneal muscle group following the peroneal challenge test.*

The null hypothesis was rejected because the data meet a .05 level of significance using a pair samples t-test (Table 5, Appendix B). Following two weeks of treatment sessions, there was a mean balance index decrease of 20% for this group (Figure 3, Appendix C).

6. *There will be no significant difference between means for peak torque to body weight ratio of the peroneal muscle group following the peroneal challenge test.*

The null hypothesis was rejected because the data meet a .05 level of significance using a pair samples t-test (Table 6, Appendix B). Subjects presented with a mean peak torque to body weight ratio increase of 17%, following six-treatment sessions (Figure 3, Appendix C).

The results of this study show that there was a 20% increase in peroneal muscle proprioception following two weeks of the peroneal challenge test (Figure 4, Appendix C). This study also determined that peroneal muscle strength increases approximately 17% following isolation during the peroneal challenge test (Figure 5, Appendix C).

Chapter Five

DISCUSSION

The primary point of this study was to determine the effectiveness of isolating the peroneal muscle group for strengthening during proprioceptive training on a multi-axial balance platform. A balance stability index and peak torque to body weight ratio were the indicators for increased performance.

Improvements/Future Research

A reason for the outcome of this study is that the research on this topic is vague. The more recent studies on peroneal proprioception and strength cite several methods of training, but do not identify any one rehabilitation method for maximizing treatment times. An improvement on this study could include an increased number of treatment sessions. This study did not allot for the effects of long term rehabilitation, only two weeks.

Another improvement that could be made is through the addition of injured subjects to the testing protocols. During the study we were unable to obtain subjects with current inversion ankle sprains. Further research should be conducted to determine to the effects of using injured subjects, or the use of the subject's dominant ankle.

Summary and Conclusions

The improvement of peroneal muscle strength and proprioception is a main concern in the rehabilitation of injured athletes. Since inversion ankle sprains make up represent 20% of all sports related injuries, therapists should have a treatment method that utilizes both time and components. The results of this study show that there was a not any significant increase in proprioception following two weeks of treatment of the Biodex Stability System. This research also determined that there was no significant increase in peak torque to body weight ratio following two weeks on treatment of the Biodex System II Dynamometer. These results could be due to the small treatment time and small sample of the population.

The study did determine that there was a large increase in both proprioception and isokinetic peroneal strength following two weeks of combined treatment using the peroneal challenge test. This information leads to the conclusion that by isolating the peroneal muscle group during proprioceptive training, athletes are able to increase the benefits of formal injury therapy. Some suggestions for sports medicine clinics are the following: that isolating the peroneal muscles can effectively increase proprioception as well as strength, the use of

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Appendix A

Instrumentation Position

Figure 1

Subject's hip and knee placement during isokinetic testing

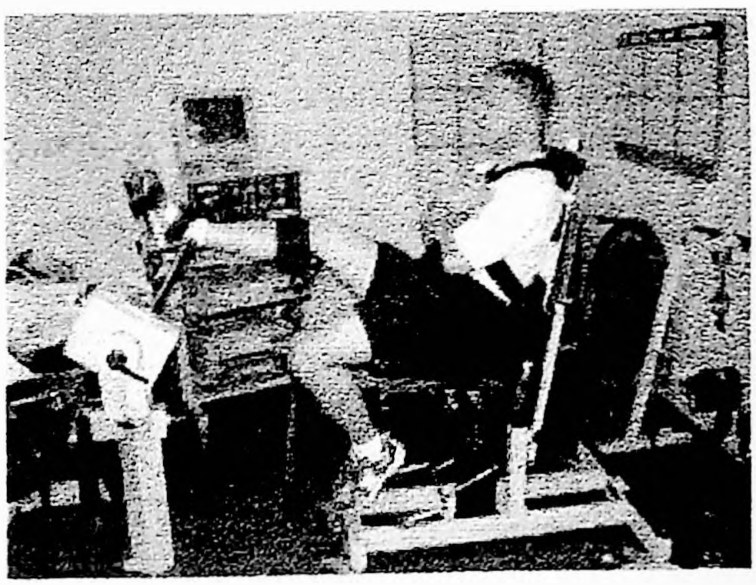


Figure 2

Placement of subject's restraint straps during isokinetic testing

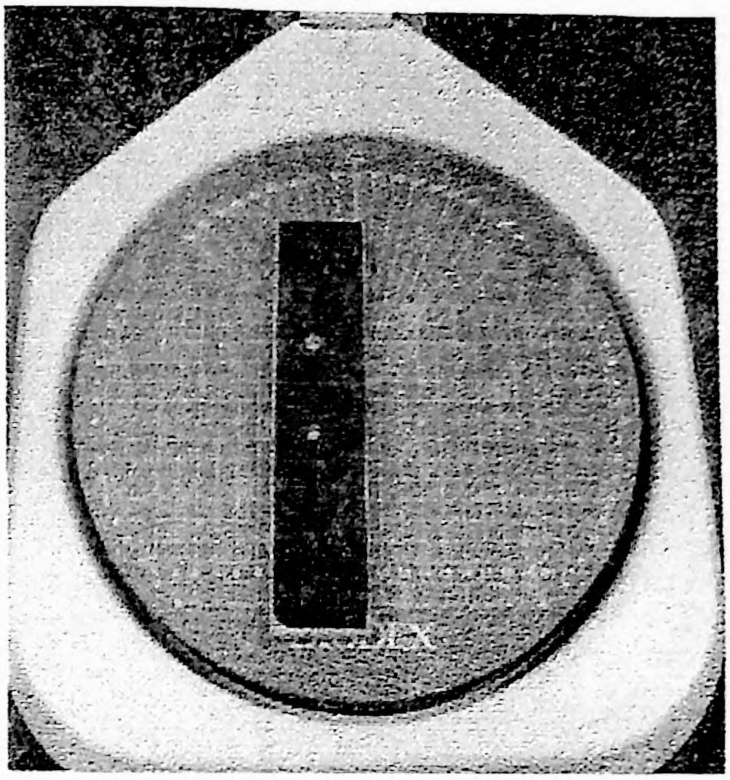


Figure 3

Placement of isolation board to multi-axial platform

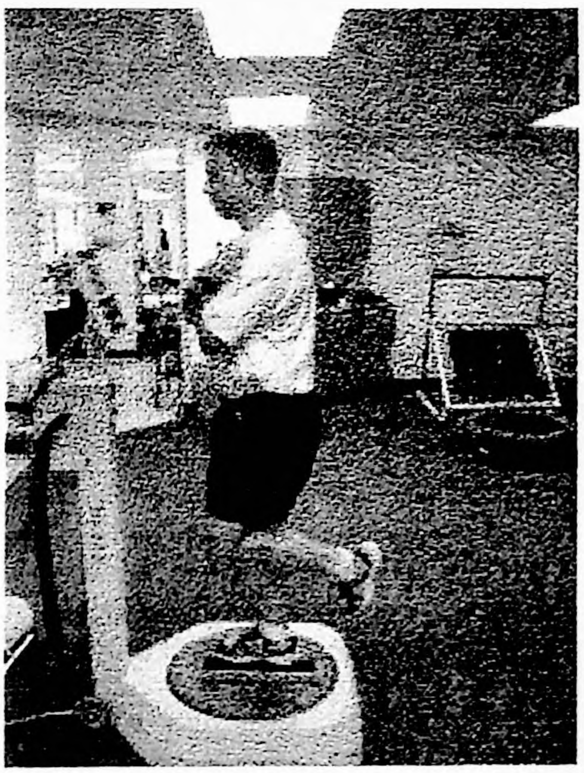


Figure 4

Patient's position of balance platform

Appendix B

Statistical Tables

Proprioception Group

Table 1

Balance Index

	Pre Test	Post Test
Mean	1.60	1.40
N	3	3
Std Dev	0.781	0.346
Std Error	0.451	0.200
Lvl of Sig	0.05	
tcv	4.303	
df	2	
t	0.795	

Table 2

Peak Torque/Body Weight

	Pre Test	Post Test
Mean	5.87	6.00
N	3	3
Std Dev	0.306	0.176
Std Error	0.458	0.265
Lvl of Sig	0.05	
tcv	4.303	
df	2	
t	1.109	

Strength Group

Table 3

Balance Index

	Pre Test	Post Test
Mean	2.23	2.10
N	3	3
Std Dev	0.723	0.608
Std Error	0.418	0.351
Lvl of Sig	0.05	
tcv	4.303	
df	2	
t	1.512	

Table 4

Peak Torque/Body Weight

	Pre Test	Post Test
Mean	6.13	6.97
N	3	3
Std Dev	1.450	0.835
Std Error	1.767	1.020
Lvl of Sig	0.05	
tcv	4.303	
df	2	
t	3.571	

Legend

Mean:	Average for group
N:	# of total subjects
Std Dev:	Variation of scores in a distribution
Std Error:	Standard deviation of sampling distribution
Lvl Sig:	Probability of making a Type I error
tcv:	Criteria for null hypothesis rejection
df:	# of subject - 1
t:	Score for tested data

Peroneal Challange Group

Table 5

Balance Index

	Pre Test	Post Test
Mean	1.86	1.53
N	4	4
Std Dev	0.411	0.206
Std Error	0.340	0.170
Lvl of Sig	0.05	
tcv	3.182	
df	3	
t	**5.422**	

Table 6

Peak Torque/Body Weight

	Pre Test	Post Test
Mean	7.48	8.90
N	4	4
Std Dev	2.723	1.362
Std Error	3.304	1.652
Lvl of Sig	0.05	
tcv	3.182	
df	3	
t	**3.994**	

Legend

Mean:	Average for group
N:	# of total subjects
Std Dev:	Variation of scores in a distribution
Std Error:	Standard deviation of sampling distribution
Lvl Sig:	Probability of making a Type I error
tcv:	Criteria for null hypothesis rejection
df:	# of subject - 1
t:	Score for tested data
####:	Null hypothesis is rejected

Appendix C

Graphs

Figure 1

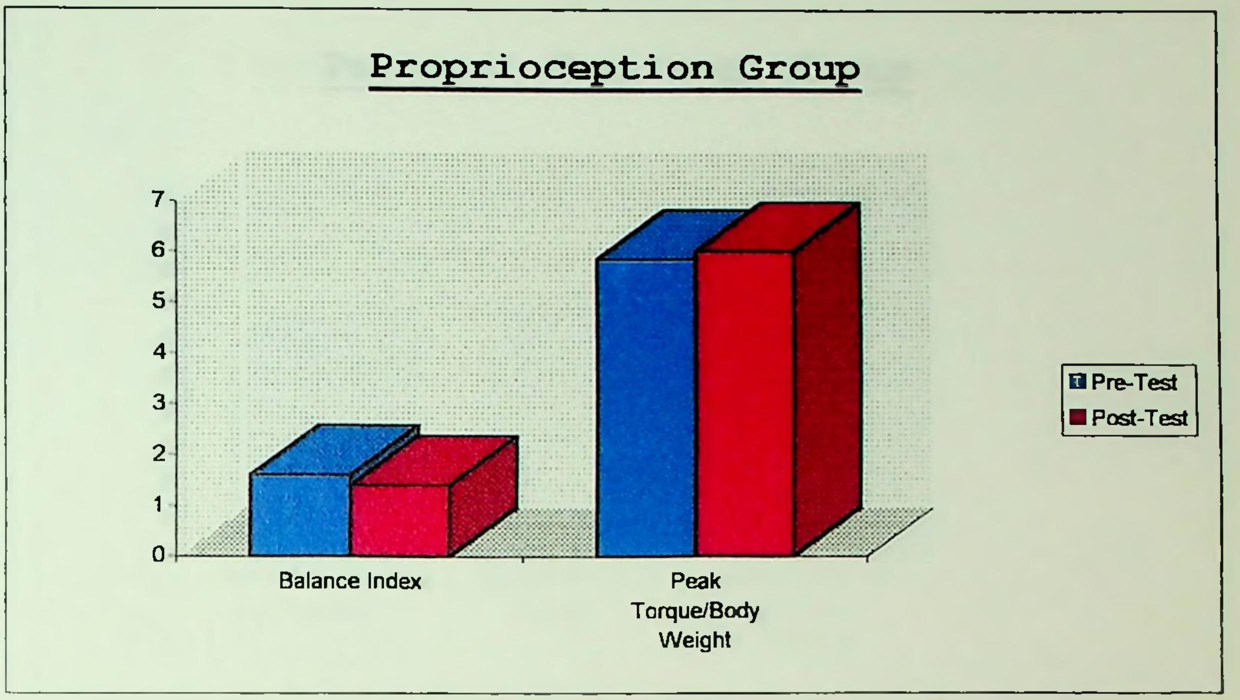


Figure 2

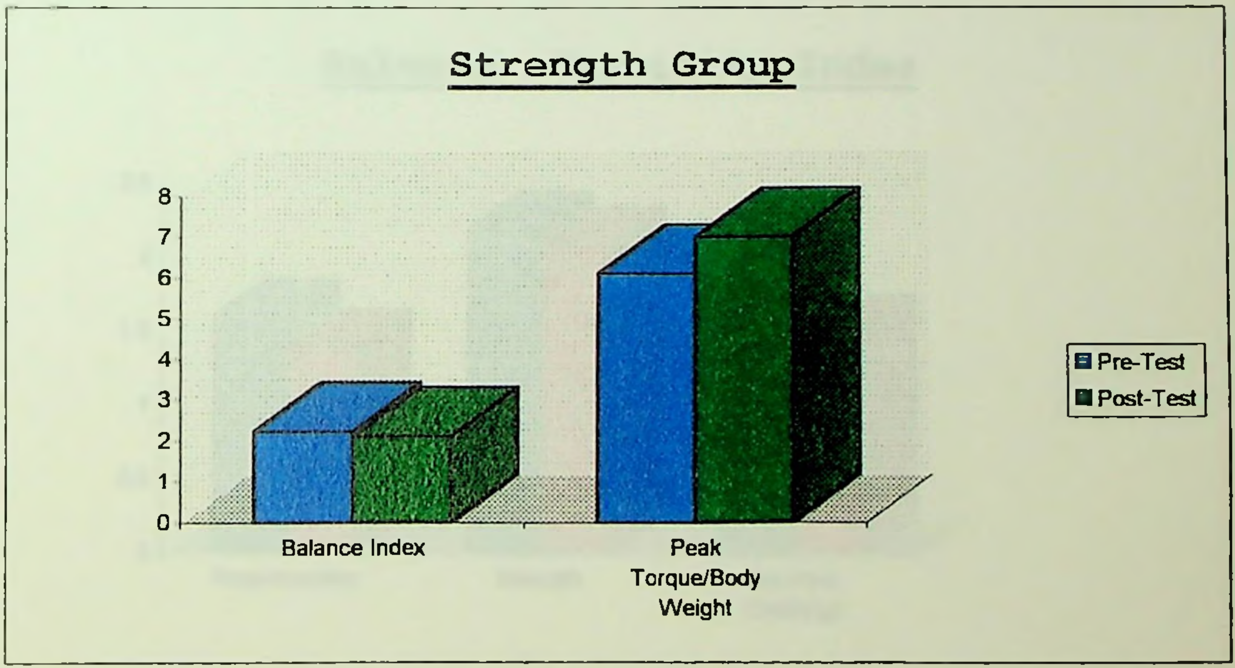


Figure 3

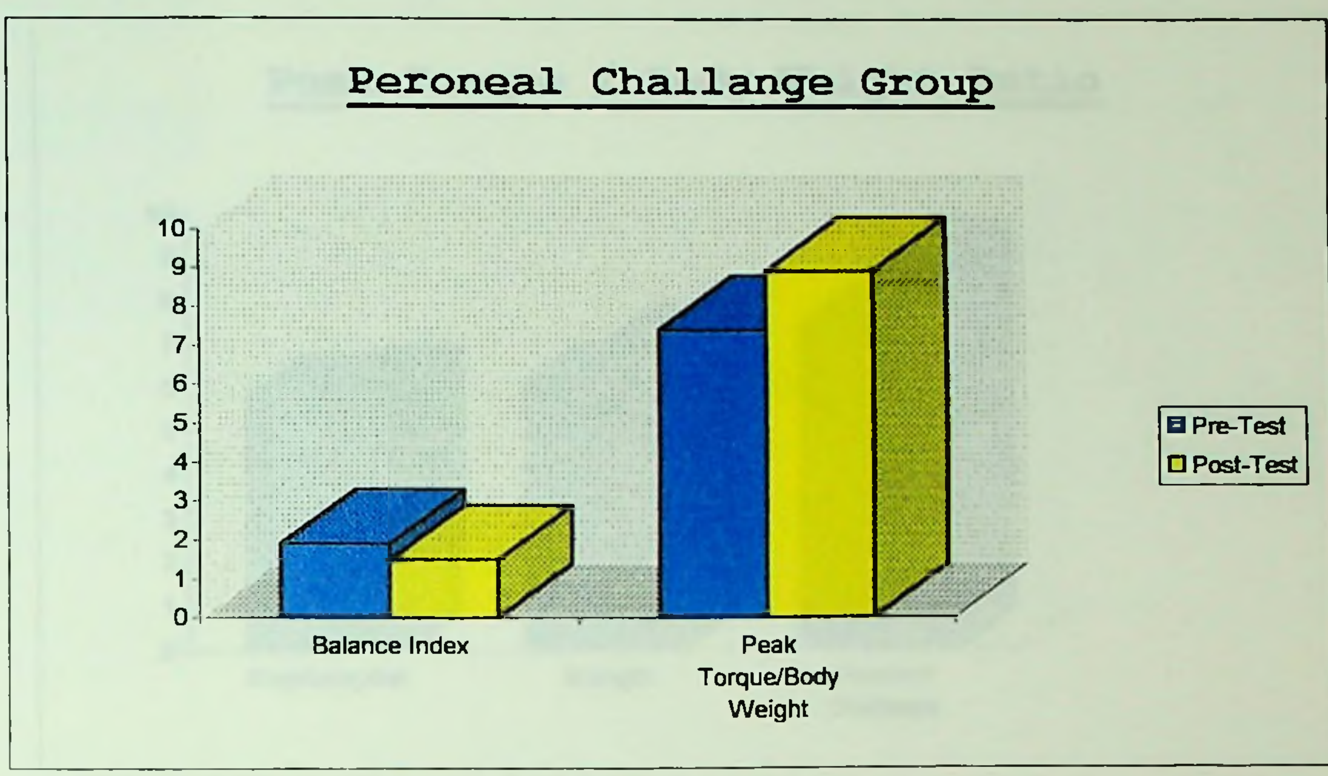


Figure 4

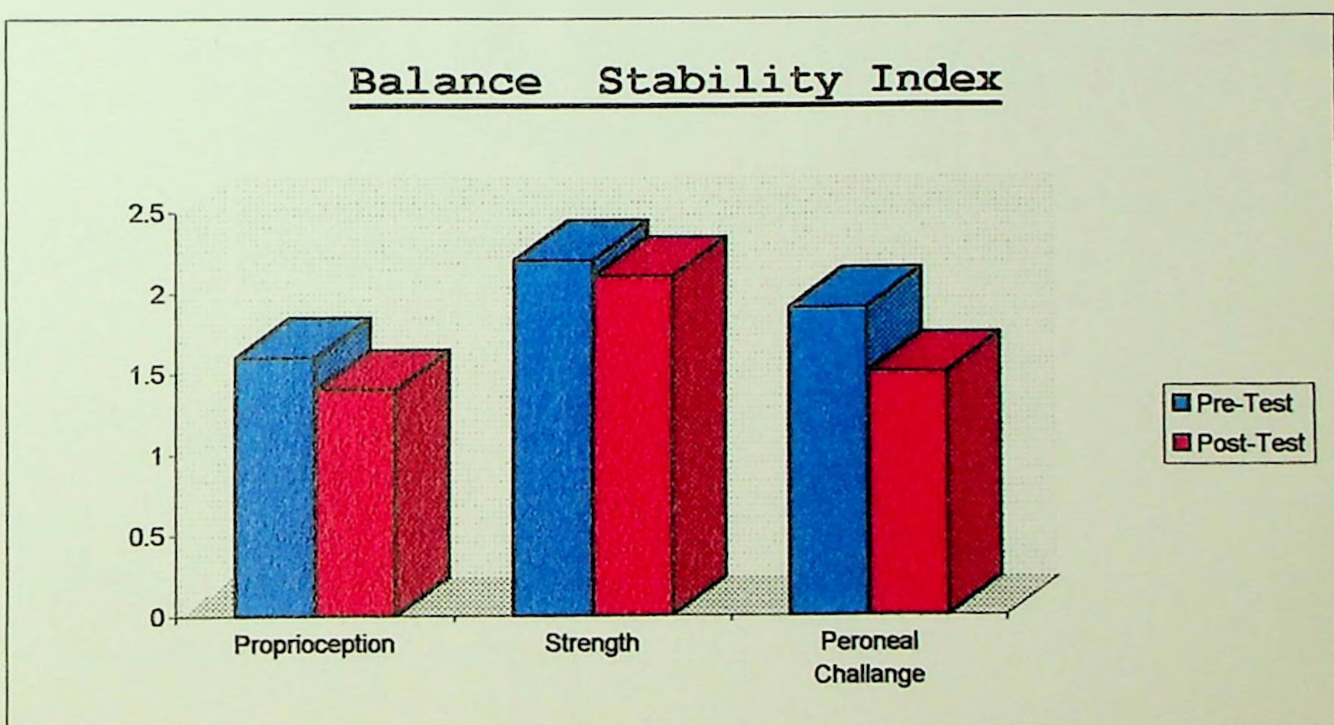
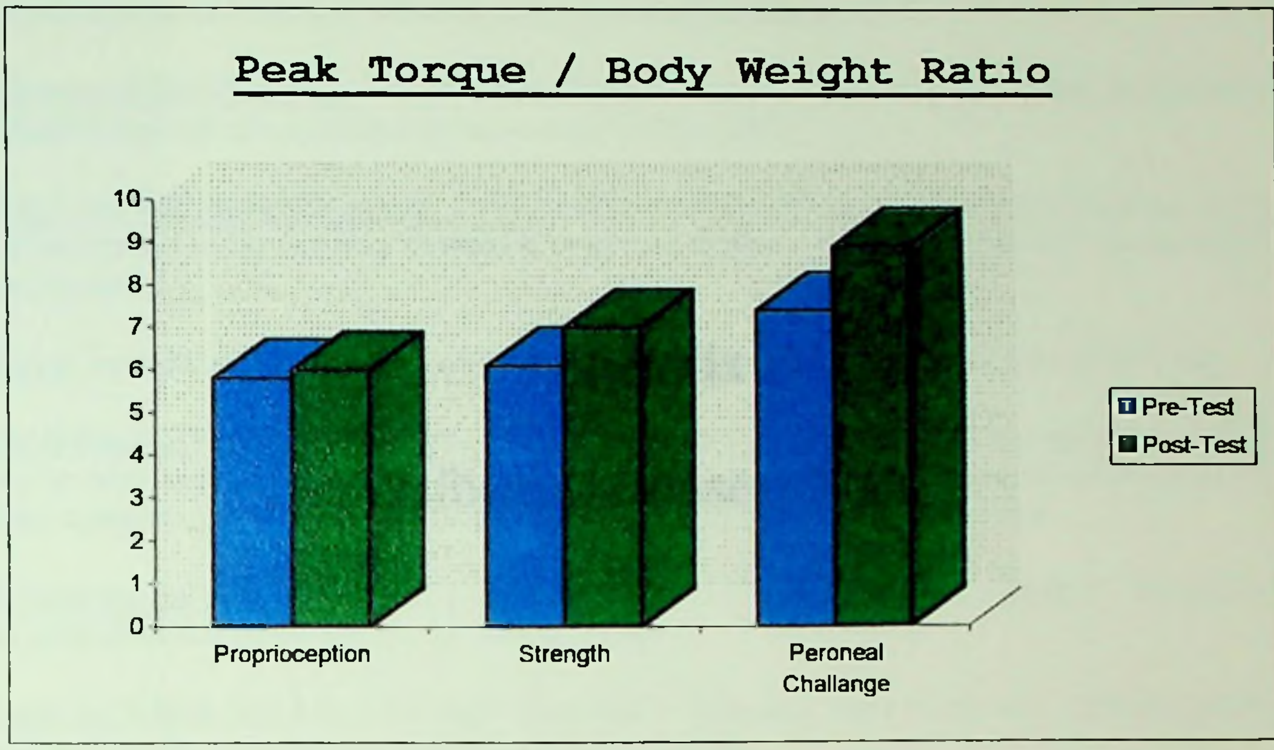


Figure 5


Peak Torque / Body Weight Ratio
10
9
8
7
6
5
4
3
2
1
0
Proprioception
Strength
Peroneal Challange
Pre-Test
Post-Test

Appendix D

Informed Consent Form

Informed Consent Agreement

Project Title: Isokinetic dynamometer versus a multi-axial stability platform in the proprioception and strength training of the peroneal muscle group.

Purpose of the Research: The purpose of this research is to determine the most appropriate and effective method of rehabilitating musculature of the ankle

What you will do in this study: I will provide a brief medical history. I will perform a strength test on my lower leg and then perform a single leg balance test. These tests will be repeated 7 total times.

Risks: I understand that I could sustain an ankle sprain or a muscle strain in my lower leg.

Confidentiality: This information obtained in this experiment will remain confidential as the law and institutional policy allows. The information may be reviewed by appropriate Federal and State agencies as well as the Marshall University Institutional Review Board.

Voluntary Participation: My participation in this study is completely voluntary. There will be no penalty placed upon me for not participating.

Right to Withdraw: I have the right to withdraw from this study at anytime without penalty. I will inform the experimenter and leave the testing area.

Payment: I will receive no payment for participating in this study. In the event of injury or illness as direct result of participation in this research study, no compensation, financial or otherwise will be available from the investigator, Healthsouth Western Hills or Marshall University.

Contact: If I have any questions about this study, I may call Eric Johnson at (304) 485-7384 extension 5003 or Dr. Dan Martin at (304) 696-2412. If I have questions regarding my rights as a research subject, I may contact Dr. Henry Driscoll, IRB Chairman, at Spring Valley Drive, Huntington, WV 25704 or phone (304) 696-7320.

Agreement: I have read the consent form and understand the nature of this study. I agree to participate in the research study described above.

Signature: ____________________________________ Date: ________________

Witness: ____________________________________ Date: ________________

* You will receive a copy of this agreement for your records.