THE EFFECT OF ANKLE KINESIO TAPE ON SINGLE LEG BALANCE AND ATHLETES' PERCEPTIONS OF ITS EFFECTIVENESS

By

Derek Nichols

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In partial fulfillment of the requirements for the degree,
Master of Science in Human Performance and Physical Education,
has been approved and accepted by the following:

Chris Gilmer — 12-2-16
Dr. Chris Gilmer — Date
Director of the Graduate School

Tracey L Robinson — 12-1-2016
Dr. Tracey L. Robinson — Date
Chairperson of Thesis Committee

Thesis Committee Members:

Tracey L Robinson — 12-1-2016
Dr. Tracey L. Robinson — *Date*

Brian M Zuleger — 12-1-2016
Dr. Brian Zuleger — *Date*

Josh Dreher — 11/28/16
Josh Dreher MS, ATC — *Date*

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Abstract

Purpose: The purpose of this study was to determine if an application of kinesio tape (KT) to the ankle is an effective measure in aiding balance using a dynamic measure of balance, the star excursion balance test (SEBT). A structured open-ended questionnaire was also administered to determine if participants believed the KT actually worked or if it is merely a placebo effect. **Methods:** Twenty NCAA Division II collegiate men's and women's soccer, baseball, and women's lacrosse players (10 males and 10 females) volunteered to be in this study. The mean age of participants was 21.0 ± 1.26 years, height of 62.8 ± 4.5 inches, weight of 158.9 ± 29.03 lbs. and mean leg length of 92.35 ± 7.59 cm. All participants completed the SEBT under three conditions in random order: the kinesio tape (KT), placebo tape (PT), and the control (no tape, NT). All subjects had 6 practice trials in each of the 8 directions of SEBT for the dominant leg to become familiar with the task. The dominant foot was the leg in which the tape was applied and the leg used during the SEBT to balance on. The three reaches in each direction of SEBT were recorded, and the average of the three calculated and used for analysis. Once done with all three conditions for the SEBT test, each participant filled out a structured, open-ended questionnaire about their perceived perceptions of the tape conditions. **Results:** The results from this study showed no significant ($p > 0.05$) differences among the three tape conditions during the SEBT overall; although two SEBT directions (Anterior Lateral and Lateral) showed significant ($p < 0.05$) differences in reach differences. The Anterior Lateral directions showed significant ($p < 0.05$) differences in reach distance between the KT and PT conditions. The KT condition had significantly further reach distances than the PT, although the KT didn't have any significant differences with the no tape condition ($p > 0.05$). The Lateral SEBT directions showed significant ($p < 0.05$) differences in reach distance for NT and PT conditions. The NT condition had significantly ($p < 0.05$) further reach distances than the PT, although NT didn't have any significant ($p > 0.05$) differences with the KT condition. Through the questionnaire, results showed that the majority of participants ranked NT as the most effective in aiding balance (45%), followed by KT (35%), and PT (20%). **Conclusion:** This study would suggest that although KT had no effect on aiding balance during the SEBT, one-third of the participants perceived KT as the most effective in aiding balance during the SEBT, due to improved perceptions of stability, confidence and reassurance with the KT in place. Overall, none of the tape conditions for this study showed significant differences during the SEBT, and 45% of the participants perceived NT as the most effective when performing the SEBT dynamic balance test.

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Chapter 1: Introduction

Taping is widely used in the field of rehabilitation as both a means of treatment and prevention of sports related injuries (Aytar et al., 2011). The essential function of most taping techniques is to provide support during movement (Aytar et al., 2011). Some believe that the tape serves to enhance proprioception and motor function, and therefore reduces the incidence of injuries (Aytar et al., 2011). Proprioception is a specialized variation of the sensory modality of touch that encompasses the sensation of joint movement (kinesthesia) and joint position sense, allowing you to control the joint before injury occurs (Baltaci & Kohl, 2003). The therapeutic effects of taping include minimizing pain, increasing muscular strength, improving gait pattern and enhancing functional outcome of patients with sports injuries, osteoarthritis and patellofemoral pain syndrome (Aytar et al., 2011). Adhesive tape is frequently used for athletes, with the most common being non-elastic tape and elastic tape (Haung, Hsieh, Lu, & Su, 2011). Non-elastic tapes are usually used to help misalignments of the body or extremities, or they serve as a support function to joints and muscles, usually referred to as athletic tape or leukotape (Haung et al., 2011). Non-elastic tape is very rigid, strong, doesn't lengthen, and tears very easy, whereas elastic tape is flexible, hard to cut, and has a lot of elasticity, being able to lengthen and return to its original state. Elastic tape is usually applied on an athletic field or during rehabilitation therapy; it is also referred to as elastikon or kinesio tape (Haung et al., 2011).

Over recent years, the use of kinesio tape (KT) has become increasingly popular, and is designed to mimic the qualities of human skin, having roughly the same thickness as the epidermis and the ability to stretch between 30 and 140% of its resting length (Aytar et al., 2011). Depending on the amount of stretch applied to the tape during application, KT tape is proposed to have several benefits, including a positional stimulus through the skin, align fascia tissues, create more space by lifting fascia and soft tissue about the area of pain/inflammation, provide sensory stimulation to assist or limit motion, and to assist in the removal of edema by directing exudates toward a lymph duct (Aytar et al., 2011).

Kinesio tape (KT) was developed by Dr. Kenzo Kase, an American trained Japanese chiropractor and acupuncturist in the 1970's (Aktas & Baltaci, 2011). Kinesio tape is a thin, cotton, porous fabric with acrylic adhesive that is non-medicated and latex free, that can be comfortably worn for 3-4 consecutive days (including in the shower), without compromising the adhesive quality (Aktas & Baltaci, 2011). Although KT research is limited, several studies have supported the efficacy of this treatment technique for addressing acute injury inflammation, promoting a faster return to activity, enhancing proprioception training, reducing pain, promoting neurological function post-injury, and reducing muscle imbalances (Aktas et al., 2011). The practice gained international exposure at the 2008 Beijing Olympics Games, where athletes from various sports (track and field, tennis, cycling, and volleyball) wore kinesio tape (O'Sullivan & Bird, 2011). These athletes wore the tape in many different areas of the body, including but not limited to the shoulder, ankle, back, knee and calves. The national television exposure during the Olympics has been extremely beneficial for the popularity and use of kinesio taping (Ujino, Eberman, Kahanov, Renner, & Demchak, 2013).

From this increase of exposure during the Beijing Olympics, kinesio tape has become a popular trend not only for athletes but in the general population to help with multiple conditions. The use of taping could potentially increase ankle stiffness thus facilitating the role of the postural control system in controlling body sway, increasing balance through stabilization of the ankle joint (Cortesi, Cattaneo, & Jonsdottir, 2011). The kinesio taping method has different types of applications to a variety of joints or muscles and different elastic characteristics (Cortesi et al., 2011). The elastic proprieties of the tape allow for it to be stretched to 140% of its original length, and have general shapes or techniques for application. Kinesio tape may be used to facilitate or inhibit muscle function in terms of muscle recruitment, and it may increase range of motion through activation of muscles, and increasing joint stability by supporting the joint (Cortesi et al., 2011). Kinesio tape may also help a muscle that is damaged, through the extra support from the tape and having the same line of pull that the damaged muscle has (Cortesi et al., 2011). Similar to other taping techniques (McConnell taping), kinesio tape can be used to support joints, reduce pain and change peripheral blood flow (Cortesi et al., 2011).

Ankle sprains are common in sports involving running, cutting and jumping, and particularly when in close proximity to other players (Eisen, Danoff, Leone, & Miller, 2010). The usual mechanism is landing on another player's foot when jumping, being forced into plantar flexion and inversion, stretching and sometimes tearing ligaments of the ankle (Eisen et al., 2010). Other risks of ankle injuries include intrinsic factors, such as unstable postural sway, muscle weakness and imbalance, poor flexibility or a hypermobile ankle joint, poor proprioception, previous predisposing injury, gender and anatomical mal-alignment of the ankle and foot (Eisen et al., 2010). Functional instability is defined as "the occurrence of recurrent joint instability and the sensation of joint instability because of the contributions of any neuromuscular deficits", and becomes evident in up to 20-42% of the patients suffering from an acute ankle injury (Eisen et al., 2010).

With this high prevalence of ankle sprains in athletics, tape has been used for many years to prevent ankle sprains from occurring or re-occurring. The application of tape may improve proprioception abilities by increasing stimulation of cutaneous mechanoreceptors within the skin, which increases pressure on underlying muscles, therefore having an effect on the joint proprioception and increasing balance (Aarseth, 2013). Proprioception is defined as a specialized variation of the sensory modality of touch that includes the sensation of joint movement and joint position (Miralles, et al., 2014). Joint position sense is the participant's ability to actively reproduce joint position and is commonly used to assess proprioception in body regions (Miralles et al., 2014). Proprioception input is received from the peripheral afferents including muscle spindles, joints and cutaneous receptors, and Golgi Tendon Organs (Simon, Garcia, & Docherty, 2014). Mechanoreceptors are one of the sensory receptors that respond to mechanical pressure, distortion or tension (Briem et al, 2011). These mechanoreceptors are around joints such as the knee and ankle offering information about the change of position, motion and loading of the joint to the CNS, which then stimulates the muscles around the joint to function appropriately (Briem et al., 2011).

Ankle joint proprioception has a special clinical interest because when decreased it is linked to ankle sprains, and it is critical to the functional success of surgical and rehabilitation treatments (Miralles et al., 2014). If there is any deficit or damage to proprioception, a change in joint stability and control of the joint motion occurs (Briem et al., 2011). Neuromuscular control is important as it helps perform specialized tasks, so when there is damage to the tissues the mechanoreceptors are impaired, which alters a person's proprioception (Aarseth, 2013). When a person's proprioception is affected, their sense of movement and joint position sense is also altered, which in turn diminishes their ability to perform specialized tasks such as balancing on a surf board or on a balance beam during gymnastics (Aarseth, 2013).

Balance is an individual's ability to maintain his or her center of gravity within the base of support (Eisen et al., 2010). Stabilization of postural equilibrium is maintained by continuous afferent and efferent signals within the sensorimotor system with feedback from somatosensory, vestibular, and visual inputs (Eisen et al., 2010). Of the three classes of afferent nerves responsible for providing proprioceptive feedback (nerves in the ligaments and joint capsule, skin, or muscle tissue), muscle afferents are thought to play the most important role (Eisen et al., 2010). Motor skill training promotes the neuromuscular mechanisms responsible for the co-contraction of agonist and antagonist muscles that enhance joint stability by increasing the sensitivity of feedback pathways and shortening the onset of contraction time for these muscles (Eisen et al., 2010). This increased joint stiffness results in less joint displacement and thus less strain on joint structures (Eisen et al., 2010). This ability to involuntarily increase joint stiffness when in an unstable situation has been shown on multiple occasions to reduce the rate of ankle sprains (Eisen et al., 2010).

Everyone has a different perception of things such as pain, culture, a song, life, effectiveness of something and in general all the ways you experience the world around you. Perception can be defined as our recognition and interpretation of sensory information, as well as how we respond to the information. The mind is a powerful entity in the world of sports (Duncan, Lyons, & Hankey, 2009). One's expectations and beliefs can play a strong role in how one performs in the gym or on the field, platform, mat, or wherever sport is played (Duncan et al., 2009). When one believes they have received a beneficial treatment, such as a nutritional supplement, and performance soars even though the nutritional supplement has no scientific backing, it is called a placebo effect (Duncan et al., 2009). The placebo effect can be very powerful and has been well researched (Duncan et al., 2009). The placebo effect is the non-specific effect of treatment attributable to factors other than specific active components (Jamshidian, Hubbard, & Jewell, 2014). These non-specific effects include physician's attention, interest and concern in a healing setting, patient and physician's expectations of treatment effects, the reputation, expense and impressiveness of the treatment, and characteristics of the setting that influence patients to report improvement (Jamshidian et al., 2014). During research, patients may develop a perception about their assigned treatment; either they believe they are more likely to be on placebo, or more likely to be on treatment, or they may have no opinion about their treatment (Jamshidian et al., 2014). Kinesio tape may have this placebo effect on people, through one believing they have received a beneficial treatment as claimed by the companies' advertising, even though there may be no scientific evidence supporting the use of kinesio tape.

Researchers have suggested that athletes are using more performance enhancing drugs or equipment in an attempt to find that "edge" over their competitors (McClung & Collins, 2007). The placebo effect is any effect attributable to a pill, potion, or procedure, but not to its pharmacologic or specific properties (McClung & Collins, 2007). Expectancy effects alone are related directly to the individual's beliefs regarding the efficacy and effect of the administered substance and, as such, arguably play the major role in the effects that are generated by (what should be) a chemically inert placebo (McClung & Collins, 2007). The capacity for the mind to affect the body has enormous ramifications, especially in sport, and research has shown expectancy to play a major role in the success of treatments within the field of performance and sport (McClung & Collins, 2007). The impacts of this expectancy can be far-reaching, encompassing perceptual, emotional, neurological, and behavioral concomitants, mediated by dopamine and endorphins (McClung & Collins, 2007). Athletes need to be educated that the improved performance associated with taking performance enhancing drugs may not only be due to the pharmacological properties of the drug but through psychologically based expectancy effect (McClung & Collins, 2007). Participants show altered blood oxygen level dependent brain responses, in the nucleus accumbens, a brain area associated with the processing of reward, and report higher subjective restlessness and "drug liking" compared to a condition in which they expected and received placebo treatment (Schwarz, & Buchel, 2015)

Despite the controversy over the scientific evidence for kinesio tape and its effectiveness, this new trend of taping with kinesio tape is commonly used with several aims, such as improvement of local circulation, pain reduction, muscle facilitation or relaxation, and increasing joint function and stability (Miralles et al., 2014). These commonly used aims of kinesio tape may have a placebo effect, persuading one that they are receiving a beneficial treatment even though there is not enough scientific evidence. The positive outcomes they may receive are through the expectancy effect, believing they will have a positive outcome, even though there may be no effect on them at all from the treatment.

Purpose

The purpose of this study was to determine if an application of kinesio tape to the ankle is an effective measure in aiding balance using a dynamic measure of balance, the star excursion balance test (SEBT). A structured open-ended questionnaire was also administered to determine if participants believe the kinesio tape actually worked or if it was merely a placebo effect.

Hypotheses

Hypothesis 1: It is hypothesized that the kinesio tape will not be effective in aiding balance due to its placebo effect.

Hypothesis 2: It is hypothesized that the kinesio tape will not be effective in aiding balance in any of the eight directions of the SEBT due to its placebo effect.

Hypothesis 3: It is hypothesized that the athletes will perceive the kinesio tape to be the most effective, with the no tape group being the least effective.

Research Questions

Research Question 1: Will the kinesio tape be effective in aiding balance compared to placebo tape and no tape groups?

Research Question 2: Will the kinesio tape be effective in aiding balance in all eight directions of the SEBT compared to placebo tape and no tape groups?

Research Question 3: What are the perceived perceptions the athletes have on the effectiveness for the kinesio tape, placebo tape, and no tape on their balance?

Delimitations

Twenty Division II collegiate men's and women's soccer, baseball, and women's lacrosse athletes' ages 18-22 years were included in this study. The study was limited to these sports as a convenience sample, due to the researcher having a good rapport with the coaches, and the coaches allowing the researcher to access the athletes as potential participants for the study. The study was restricted to athletes with no current injuries. Participants were excluded from the study if they had any lower extremity injuries, vestibular problems, visual problems, or a concussion within the past six months. A recruitment email was used to gain participants for this study. Two-inch wide Mueller kinesiology tape was used for this study. The placebo tape was two-inch Elastikon elastic tape due to its similar size and feel to the Mueller kinesiology tape. All tape was left on only on for the length of the SEBT protocol. A control group of no tape was implemented into the study. A questionnaire which consisted of structured open-ended questions about perceptions of the tape conditions during the study, which was used for every athlete to keep consistency, but doesn't allow for tailor-made questions like an in-person interview would.

Limitations

For the SEBT, there may be a learning effect, but this was potentially controlled for by having six practice trials prior to data collection, as recommended by Hertel, Braham, Hale, and Olmsted-Kramer (2006). Kinesio tape wasn't kept in place for a long period of time, limiting to only immediate effects of the tape. This study used Mueller kinesio tape so results can't be compared to other types of kinesio tape. With the questionnaire, athletes may have discussed the questions to each other since the test was not done at the same times for everybody; to control this the subjects were asked not to talk to each other about the test. All subjects were healthy, so results may not be generalized to injured individuals. Even though subjects wore sweatpants placed over the tape application, participants may still have known the differences.

Assumptions

The researcher, a Certified Athletic Trainer, applied all the taping conditions in an appropriate manner. During the study it was assumed that the kinesio tape is what is improving balance and not the placebo. It was assumed that the Star Excursion Balance Test was a reliable and valid measure of balance (Bastien et al., 2014; Gribble, Kelly, Refshauge, & Hiller, 2013; Hertel et al., 2006; Hyong & Kim, 2014; Munro & Herrington, 2013; Olmsted, Carcia, Hertel, & Schultz, 2002) It was assumed that the participants performed to the best of their abilities during the SEBT test. It was assumed that the participants did not talk about the questionnaire questions amongst each other, possibly skewing the results. It was assumed that the sweats over the tape conditions limited participants from knowing the tape that was applied.

Definition of Terms

Balance: the ability to stay upright or stay in control of body movement (Bressel, Yonker, Kras, & Heath, 2007).

Dynamic balance: maintaining equilibrium when moving (Bressel et al., 2007).

Elastikon: a high twist, cotton elastic cloth tape with a rubber-based adhesive (Williams, Whatman, Hume, & Sheerin, 2012).

Isokinetic: characterized by or producing a constant speed, related to muscular action with a constant rate of movement (Aktas & Baltaci, 2011).

Joint stability: derived from a number of structures and mechanisms, both mechanical and neural, that serves to restrict joint motion to normal anatomical limits (Blackburn, Guskiewicz, Petschauer, & Prentice, 2000).

Keloid: an area of irregular fibrous tissue formed at the site of a scar or injury (Karwacinska, et al., 2012).

Kinesio tape: a flexible, cotton, adhesive tape that was designed to mimic the qualities of skin (Williams et al., 2012).

Prophylactic: intended to prevent disease or protect against injury (Arnheim & Prentice, 2000).

Proprioception: the inborn kinesthetic awareness of body posture including movement, tension, and changes in equilibrium (Baltaci & Kohl, 2003).

Proprioceptive sense: is derived from a culmination of sensory input from specialized receptors in muscles (muscle spindle receptors and Golgi Tendon Organs), joint capsules, ligaments, and cutaneous receptors, that is conveyed to the central nervous system through afferent neural pathways (Blackburn et al., 2000). Information from these mechanoreceptors is processed to provide an efferent neural signal designed to facilitate neuromuscular control in an effort to compensate for deviations in stance or gait (Blackburn et al., 2000).

Range of motion (ROM): the amount of movement within a joint (Arnheim & Prentice, 2000).

Reliability: is the ability of a test to demonstrate the same results over time (Arnheim & Prentice, 2000).

Residual: remaining after the greater part or quantity has gone (Arnheim & Prentice, 2000).

Single leg balance: the ability to stay upright or stay in control of body movement on one leg (Bressel et al., 2007).

Static balance: maintaining equilibrium when stationary (Bressel et al., 2007).

Trigger points: small, hyperirritable areas within a muscle (Prentice, 2006).

Validity: Refers to the ability of a test to be accurate and measure what it is supposed to measure (Arnheim & Prentice, 2000).

Chapter 2: Literature Review

Introduction

Kinesio taping (KT) is a popular debate within many groups of the medical field including orthopedic clinicians, athletic trainers, physical therapists, and its use has become extremely popular among the athletic population (Williams et al., 2012). Kinesio tape is an elastic therapeutic tape used for treating sports injuries and a variety of disorders (Williams et al., 2012). Dr. Kase, an American trained Japanese chiropractor and acupuncturist created Kinesio® Tex Tape in the mid-1970s, designed to facilitate the body's natural healing process, while allowing support and stability to muscles and joints without restricting the body's range of motion (Williams et al., 2012). Kinesio tape use increased after the tape was donated to 58 countries for use during the 2008 Olympics, and was seen on high profile athletes (Williams et al., 2012). The tape is proposed to successfully treat a variety of orthopedic, neuromuscular, neurological and medical conditions (Kinesio USA, LCC, 2013). Dr. Kase claims that KT supports injured muscles and joints, helps relieve pain and inflammation by lifting the skin and allowing improved blood and lymph flow, enhances performance, and prevents injury (Williams et al., 2012).

Over the years, kinesio tape has evolved in technology and has branched out to many different brands, which include Kinesio® Tex Classic, Kinesio® Tex Gold, Mueller Kinesiology Tape, KT TAPE™, KT TAPE™ Pro. The new Kinesio® Tex Gold brings nano touch stimulation to epidermis and layers beneath, mimics gentle human touch yet provides a more effective hold, utilizes the micro-grip deep set adhesive manufacturing process to provide better grip and hold less adhesive surface area, uses a higher grade cotton with more breathability, uses a new protected weave process for improved comfort, retains the core properties for all Kinesio taping specifications, and remains hypoallergenic and latex free to serve patient populations (Kinesio USA, LCC, 2013). Mueller Kinesiology Tape claims that their product lifts the skin to help increase the natural blood flow, maintain flexibility and stability, relieve pain, enhance recovery, and help you stay in the game (Mueller Sports Medicine, Inc., 2014). Another kinesiology tape, KT TAPE™, claims to create neuromuscular feedback (proprioception) that inhibits (relaxes) or facilitates stronger firing of muscles and tendons, along with support and pain relief for muscles, tendons, and ligaments (KT Health, 2011). KT TAPE™ Pro creates support elements without the bulk and restriction commonly associated with wraps and heavy bracing, and is even waterproof with the new technology (KT Health, 2011). KT TAPE™ Pro also remains on the skin longer (up to 7 days), and is made with a new synthetic fiber instead of the original cotton (KT Health, 2011). For the purpose of this study, Mueller Kinesiology Tape will be used due to its accessibility and costs.

Many health professionals have questioned whether kinesio tape actually provides therapeutic benefits to athletes, or if it simply acts as a placebo (Williams et al., 2012). Due to KT being a relatively new trending topic, there is little current research on the effectiveness of kinesio tape and the evidence that is out there is somewhat contradictory; this warrants more research on KT. The current research provides evidence of kinesio tape on its effectiveness on proproception, pain, range of motion, strength, and realignment, with little evidence on kinesio tape for balance and stability, especially for the ankle. The purpose of this literature review is to assemble all the most recent research on kinesio tape and its effects on all of the claims that have been made, but more specifically looking at studies on ankle, kinesio tape and the Star Excursion

Balance Test (SEBT). The literature review will also incorporate aspects of qualitative research as it applies to the placebo effect.

Anatomy of the Ankle

The bones that form the ankle joint are the distal portion of the tibia, distal portion of the fibula, and the talus (Appendix A) (Arnheim & Prentice, 2000). The calcaneous also plays a critical role in the function of the ankle joint (Arnheim & Prentice, 2000). The ankle joint, or talocrural joint, is a hinge joint that is formed by the articular facet on the distal portion of the tibia, which articulates with the superior articular surface (trochlea) of the talus (Appendix A) (Arnheim & Prentice, 2000), the medial malleolus, which articulates with the medial surface of the trochlea of the talus, and the lateral malleolus, which articulates with the lateral surface of the trochlea (Arnheim & Prentice, 2000). This bony arrangement is typically referred to as the ankle mortise. Ankle movements that occur at the talocrural joint include plantar flexion and dorsiflexion (Arnheim & Prentice, 2000).

The subtalar joint, which is the other joint of the ankle, consists of the articulation between the talus and the calcaneus (Arnheim & Prentice, 2000). Ankle movements that occur at the subtalar joint include inversion and eversion. In addition to the tibiofubular ligaments, the ligamentous support of the ankle consists of three lateral ligaments and the medial, or deltoid ligament (Arnheim & Prentice, 2000). The three lateral ligaments include the anterior talofibular, the posterior talofibular, and the calcaneofibular (Appendix B) (Arnheim & Prentice, 2000). The three lateral ligaments are the primary resistance to foot inversion (Arnheim & Prentice, 2000). The deltoid ligament is triangular (Appendix B) (Arnheim et al., 2000). Which attaches superiorly to the borders of the medial malleolus and attaches inferiorly to the medial surface of the talus, to the sustenaculum tali of the calcaneus, and to the posterior margin of the navicular bone. The deltoid ligament is the primary resistance to foot eversion (Arnheim & Prentice, 2000).

The musculature of the ankle is contained within four distinct compartments, which are bounded by heavy fascia (Arnheim & Prentice, 2000). The anterior compartment contains the muscles that dorsiflex the ankle and extend the toes, and include the tibialis anterior, extensor hallucis longus, and extensor digitorum longus muscles (Appendix C) (Arnheim & Prentice, 2000). The lateral compartments, contains the peroneus longus and brevis, which evert the ankle (Appendix C) (Arnheim & Prentice, 2000). The superficial posterior compartment contains the gastrocnemius muscle and the soleus muscle; these muscles plantar flex the ankle (Appendix C) (Arnheim & Prentice, 2000). The deep posterior compartment contains the tibialis posterior, flexor digitorum longus, and flexor hallucis longus muscles, which invert the ankle (Appendix C) (Arnheim & Prentice, 2000).

Ankle Injuries

Ankle sprains are frequently cited as the most common sports related injuries and result in injury to the lateral ligaments, along with having a high re-injury rate secondary to chronic laxity of the ligaments and/or the subsequent loss of the joints sense of position caused by injury to proprioceptors (Arnheim & Prentice, 2000). The anterior talofibular ligament is the weakest of the three lateral ligaments (Arnheim & Prentice, 2000). The calcaneofibular and posterior talofibular ligaments may also be injured in inversion sprains as the force of inversion is increased (Arnheim & Prentice, 2000). Lateral ankle sprain (LAS) is among the most common injury in sport (Olmsted et al., 2002). Lateral ankle sprains are considered to account for approximately 90% of all ankle sprain injuries (Kase, 2003). The incidence of residual symptoms and development of chronic ankle instability (CAI) after LAS have been reported to be between 31-40% (Olmsted et al., 2002). When LAS occurs, damage not only occurs to the structural integrity of the ligaments but also to various mechanoreceptors in the joint capsules, ligaments, and tendons about the ankle complex (Olmsted et al., 2002). Collectively, these receptors offer feedback regarding joint pressure and tension, ultimately providing a sense of joint movement and position (Olmsted et al., 2002).

The majority of lateral ankle sprains are non-contact in nature (Wikstrom, Tillman, Chmielewski, & Borsa, 2006). Ankle sprains, which affect the stabilizing ligaments, are caused by sudden inversion forces that overwhelm the ankles' defenses (proprioception, muscular strength) (Wikstrom et al., 2006). These forces are often combined with plantar flexion and result in the stretching or tearing of the peroneal muscles and/or stabilizing ligaments (Wikstrom et al., 2006). While relatively "minor" injuries, ankle sprains can result in a great deal of missed athletic participation (Wikstrom et al., 2006).

Hootman, Dick and Agel (2007) investigated the epidemiology of collegiate injuries for 15 sports over a 16 year period. Hootman et al. (2007) found that for games, pre-season competition accounted for the lowest injury rate, whereas the in-season accounted with the highest injury rates. For practices, pre-season practices accounted for the highest injury rate with post-season having the lowest (Hootman et al., 2007). The rate of game injuries was 3.5 times higher than the rate of practice injuries (Hootman et al., 2007). More than 50 percent of all reported injuries were to the lower extremity in both practices and games, with knee and ankles injuries accounting for most of the lower extremity injuries (Hootman et al., 2007). More than

27,000 ankle ligament sprains were reported over the 16 years, with an average of 1,700 per year (Hootman et al., 2007). Football and men's basketball had the highest rates of ankle ligament sprains (Hootman et al., 2007). Ligament injuries to the ankle are the most common injury occurring, regardless of sport or exposure type (Hootman et al., 2007). Ankle ligament injuries represented 14.8% of all reported injuries. Prophylactic bracing or taping and neuromuscular/balance exercise programs can reduce the rate of lower extremity injuries by as much as 50%, due to increasing proprioception, strength and aiding in protection of the extremity (Hootman et al., 2007).

When a lateral ankle sprain occurs, damage not only happens to ligaments, but also to the many mechanoreceptors in the joint capsules, tendons, and ligaments within the ankle (Olmsted et al., 2002). These receptors offer feedback on joint pressure and tension, providing sense of joint position and movement (Olmsted et al., 2002). Through afferent nerve fibers, this information is combined with the visual and vestibular sensory systems into a complex control system that acts to control posture and coordination (Olmsted et al., 2002). When afferent input is altered or damaged after injury, corrective muscular contractions may be altered (Olmsted et al., 2002). Thus, damage to the mechanoreceptors surrounding the ankle joint with a lateral ankle sprain may contribute to functional impairments and chronic instability following the initial injury (Olmsted et al., 2002).

Proprioception

Proprioception is a specialized variation of the sensory modality of touch that includes the sensation of joint movement and joint position (Miralles et al., 2014). Kineiso tape is proposed to cause an increase in proprioception through increased stimulation to cutaneous mechanoreceptors (Halseth, McChesney, Debeliso, Vaughn, & Lien, 2004). In 2004, Halseth et al. designed an experiment to determine if kinesio taping the anterior and lateral portion of the ankle would enhance ankle proprioception compared to an untaped ankle. Thirty subjects (15 males and 15 females) participated in the study (Halseth et al., 2004). Reproduction of joint position sense (RJPS) was measured in accordance with the subjects' ability to actively recreate a randomly selected target position (Halseth et al., 2004). These ankle measures were taken for both planter flexion and inversion with 20 degrees of planter flexion before and after the application of kinesio tape (Halseth et al., 2004). To ensure RJPS was affected only by mechanoreceptors within the ankle, subjects were blindfolded and asked to wear headphones playing white noise to ensure both visual and auditory cues did not affect the results (Halseth et al., 2004). RJPS was assessed in conditions of no ankle tape and kinesio tape, and all subjects were placed in a seated position with the foot resting on the footplate of the apparatus (Halseth et al., 2004). RJPS measures were taken by passively placing the dominant ankle to a random target angle and asking the subject to actively reposition their ankle to the target angle from a neutral starting position (Halseth et al., 2004).

Target angle positions in the plantar flexion varied from only 1 degree to 35 degrees and inversion with 20 degrees of plantar flexion had an angular position range from 1 to 10 degrees, with five trials given at each range of motion (Halseth et al., 2004). Subjects were passively passed to a random target position for five seconds, asked to remember the target position, and then passively returned to their neutral starting position (Halseth et al., 2004). Subjects were then asked to actively reposition their foot as closely to the target angle as possible (Halseth et al., 2004). Constant error and absolute error values were examined by taking the difference between the target angle and the trial angle for each subject, constant error looked at the direction of imprecision, measuring the number of positive or negative degrees the actively reproduced ankle position from the target position (Halseth et al., 2004). Absolute error took only the number of degrees that actively reproduced ankle position from the target position (Halseth et al., 2004). Results indicated that the kinesio tape group showed no change in constant and absolute error for ankle RJPS when compared to the no tape results using the same motions, so the application of kinesio tape does not appear to enhance proprioception (Halseth et al., 2004).

Proprioception senses include measures of kinesthesia, joint sense, and force sense (Simon et al., 2014). Kinesthesia and joint reposition sense have been used to assess proprioception function at the ankle, however force sense has received less attention (Simon et al., 2014). Force sense is a conscious proprioceptive sense that measures the ability of an individual to detect muscular force or tension (Simon et al., 2014). Simon et al. (2014) investigated the effect of KT on force sense in the ankle. Twenty-eight subjects were involved, split into two groups: the control group had healthy ankles with no history of injury, and then functional ankle instability (FAI) group had a history of an ankle sprain (Simon et al., 2014). The FAI group reported their last ankle giving way episode within one to six months prior to the testing date, and felt unstable during sports or recreational activity (Simon et al., 2014). On the first day, subjects completed maximal voluntary isometric contraction (MVIC) testing followed by initial force sense testing (Simon et al., 2014). Then, the FAI group received the KT tape, and the subjects in the control group received no tape (Simon et al., 2014). After the intervention, the subjects performed a second force sense assessment (Simon et al., 2014). On day two, which was 72 hours after day one, subjects completed a third force sense assessment (Simon et al., 2014).

At baseline and immediately after application of KT, subjects in the FAI group had significantly more force sense errors than those in the control group (Simon et al., 2014). Results showed that KT improved force sense reproduction in subjects in the FAI group after they wore the tape for 72 hours (Simon et al., 2014). The control group didn't have significant improvements but the results showed that KT could improve proprioception to the level that would be similar to those who have never sustained injury (Simon et al., 2014).

The KT action mechanism on proprioception is still not well established (Miralles et al., 2014). Due to being an elastic adhesive tape, KT does not limit functional performance and may enhance functional performance through proprioception and muscle activation rather than mechanical support, which limits joint movement (Miralles et al., 2014). Miralles and colleagues (2014) investigated the effects kinesio tape has on ankle proprioception. Sixty-eight healthy volunteers (40 females and 28 males), 18 to 35 years old participated in the study. Subjects were excluded if they had any joint laxity, more than three ankle sprains in their lives or one in the last year, any neurological or circulatory diseases (Miralles et al., 2014). Joint position sense (JPS) was measured through the Difference of Error (DE) and the Deviation of the Target Angle (DTA) using the electronic plate (Pro-kin 200W) a proprioception unstable system (Miralles et al., 2014). Subjects were randomly split into taped or no tape treatment groups (Miralles et al., 2014). JPS was assessed before the KT was placed, immediately after and 48 hours later with the tape still on (Miralles et al., 2014). The JPS had seven established positions: neutral position, 5 degrees of plantar flexion, 5 degrees of dorsiflexion, 5 degrees inversion, 5 degrees of eversion, 10 degrees plantar flexion, 10 degrees of dorsiflexion (Miralles et al., 2014). During the test, the subjects were barefoot to limit undesired cutaneous feedback, and were blindfolded to prevent any visual information from distorting the test, and auditory input was limited by keeping the room silent (Miralles et al., 2014). Results indicated that forty-eight hours after application of the KT the 10 degrees of plantar flexion position worsened compared to the control group, who actually improved (Miralles et al., 2014). For all the other positions there was no significant differences between the interventions, with neutral being the most accurate reproduced position (Miralles et al., 2014). These results showed that KT had no significant effect on ankle JPS, and is not justified as a prevention technique or to improve proprioception during rehabilitation (Miralles et al., 2014).

Balance

Balance relies on a very complex interaction between sensory and motor systems; a precise perception of physical stimuli by sensory receptors of the somatosensory, vestibular, and visual systems and the combination of these inputs is essential for good balance (Cortesi, et al., 2011). Disorders in the sensory system can lead to inadequate motor responses, leading to poor balance (Cortesi et al., 2011). Cortesi et al. (2011) assessed the effectiveness of kinesio taping applied to the back of the ankles in improving body stability in standing balance with eyes closed in individuals with Multiple Sclerosis (MS). Fifteen subjects with MS were recruited for a repeated measures study with kinesio tape and no tape conditions (Cortesi et al., 2011). The subjects were tested for static balance using the Berg Balance Scale (BBS), the Medical Research Council (MRC) scale for strength, and the visual analogic scale (VAS) was administered to assess patient's walking perception (Cortesi et al., 2011). All participants were baseline tested without tape (Cortesi et al., 2011). Participants were retested immediately after application of the tape; the tape was then left on for two days and participants were retested a day after the removal of the tape (Cortesi et al., 2011). Results showed that in the mediolateral plane there was no significant difference among conditions, with the anterior-posterior plane showing significant differences between baseline and taping condition to length, mean and velocity of sway (Cortesi et al., 2011). The researchers suggest that kinesio tape may be useful in immediately helping in balance and stabilizing body posture, but only in the anterior-posterior plane, for people with Multiple Sclerosis (Cortesi et al., 2011). Although kinesio tape was useful in helping balance and stabilizing body posture for people with multiple sclerosis, results may not be generalizable to a healthy population.

Achatz's (2015) attempted to determine if an application of kinesio tape, placebo tape, or no tape to the knee was an effective measure in aiding static single leg balance (Achatz, 2015). Thirty (15 males and 15 females) Division II athletes were recruited to participate in the study (Achatz, 2015). Participants were randomly assigned to a starting group (control, kinesio tape, or placebo tape) and all participants completed all three conditions (Achatz, 2015). Single leg Balance Error Scoring System (BESS) testing was performed by the participants on their dominant leg in each testing condition in a randomized order (Achatz, 2015). Total BESS scores were collected by combining the total amount of errors from the firm and foam single leg conditions (Achatz, 2015). The results of the study suggest that kinesio tape and placebo tape, on Division II athletes, are not effective measures in aiding static single leg balance, due to the increased number of errors for the kinesio tape and placebo tape conditions, compared to the low number of errors for the control tape conditions (Achatz, 2015). In fact, balance appeared to worsen with tape compared to the no tape (control) condition (Achatz, 2015).

Balance impairments are due to combined effects of a lack of postural control strategies, weakness, and a lack of reliable sensory information (Cortesi et al., 2011). These balance impairments may lead to injuries to many different muscles, bones, ligaments, or tendons (Cortesi et al., 2011). Ankle sprains are associated with certain chronic conditions including functional instability, and ankle osteoarthritis (Fayson, Needle, & Kaminski, 2013). Several risk factors for initial and recurrent ankle sprains have been proposed, including alterations in static and dynamic balance mechanisms of the ankle joint (Fayson et al., 2013). Static balance is defined as the mechanical restraint provided by the passive structures of the ankle including bones, ligaments, and the joint capsules (Fayson et al., 2013). Dynamic balance includes the ability of the musculotendinous unit to prepare for and react to unexpected joint loads (Fayson et al., 2013). In order to improve both static and dynamic balance in the ankle, bracing and taping have been widely used as both a rehabilitative and preventative intervention for ankle sprains, by providing support and enhancing proprioception (Fayson et al., 2013).

Fayson, Needle and Kaminski (20013) investigated the effects of ankle kinesio tape on ankle stiffness and dynamic balance. Thirty women, with no history of ankle injury, fracture, or surgery to the legs and who had no lower extremity injuries within six months of testing were recruited for the study (Fayson et al., 2013). The participants were tested for passive ankle laxity, stiffness, and time to stabilization following forward, backward, lateral, and medial single leg hops (Fayson et al., 2013). The subjects were baseline tested without KT tape, tested immediately after application of KT tape, and following 24 hours when the tape was still applied (Fayson et al., 2013). The findings indicated that immediate application of KT tape for the ankle joint may be beneficial in limiting passive anterior stiffness, despite not altering peak laxity

(Fayson et al., 2013). This suggests that KT may show some support in terms of stiffness to the ankle joint, but the ligaments of the ankle still show the same laxity under stress (Fayson et al., 2013). KT tape also had an increase in ankle stiffness following 24 hours of use, suggesting that KT tape may be used for longer amount of time than traditional tape to aid in prevention of ankle sprains (Fayson et al., 2013). There was no effect of KT tape on time to stabilization, showing KT has no effect on proprioception in the ankle (Fayson et al., 2013). These results suggest that KT tape may improve static restraint in the ankle joint without improving peak motion or dynamic balance (Fayson et al., 2013).

Star Excursion Balance Test (SEBT)

Clinicians and health professionals often use postural control (balance) assessments to evaluate risk of injury, and level of improvement after intervention for an injury (Gribble et al., 2012). Balance and postural control can be categorized into two groups: static and dynamic balance (Gribble et al., 2012). Static balance tasks require the individual to establish a stable base of support and maintain the position while minimizing body and segment movement during the assessment (Gribble et al., 2012). These measurements can be conducted with equipment, such as a force platform, or valid, reliable clinical scales, like the Berg Balance Scale or the Balance Error Scoring System (Gribble et al., 2012). Dynamic balance involves some level of expected movement around the base of support (Gribble et al., 2012). This might involve tasks such as jumping or hopping to a new location and immediately attempting to remain as motionless as possible, or attempting to create purposeful limb movements (reaching) without compromising the already established base of support (Gribble et al., 2012). Even though dynamic balance assessments do not exactly replicate sport participation, they are more specific and practical than static balance assessments when mimicking the demands of physical activity (Gribble et al., 2012).

One dynamic assessment that has gained popularity in the clinical settings is the Star Excursion Balance Test (SEBT) (Gribble et al., 2012). SEBT is a reliable measure and a valid dynamic test to predict risk of lower extremity injury, and for identifying dynamic balance deficiency in individuals with lower extremity conditions(Gribble et al., 2012). SEBT is also used to identify responsive measurements to training programs in healthy participants and those with lower extremity conditions, showing strong improvements in dynamic stability (Gribble et al., 2012). The SEBT is a series of single limb squats using the non-stance limb to reach as far as possible to touch a point along 1 of 8 designated lines on the ground (Gribble et al., 2012). The lines are arranged in a grid that extends from a center point and arranged 45 degrees from each other (Appendix D) (Gribble et al., 2012). The reaching directions for the SEBT are named in orientation to the stance limb including anterior, anterolateral, lateral, posterolateral, posterior, posteromedial, medial, and anteromedial (Gribble et al., 2012). The participant establishes a base of support, then while standing on a single limb with hands on hips, the participant reaches as far as possible with the opposite limb along the line of each reaching direction, touching it with the most distal portion of their foot, and then returning it to the beginning position in the center of the grid (Gribble et al., 2012). The trial is not considered complete if the participant touches heavily or comes to rest at the touch down point, has to make contact with the ground with the reaching foot to maintain balance, or lifts or shifts any part of the foot of the stance limb during the test (Gribble et al., 2012). The reach distances measured are used to determine dynamic balance (a farther distance reach indicates better dynamic balance) (Gribble et al., 2012). The three reach distance lengths in each of the eight directions are then averaged to find the reach distance length that gets analyzed (Eisen et al., 2010). To normalize the reach length, the investigator divides the reaching distance by the length of the stance lower limb, then multiplies it by 100 (Eisen et al., 2010). This normalizes the results, since someone with long legs will generally have a longer reach compared to someone with short legs (Gribble et al., 2012). These results can be compared between injured and uninjured limbs, or before and after an intervention to determine decreases or improvements in dynamic balance (Gribble et al., 2012).

Gribble, Kelly, Refshauge, and Hiller (2013) investigated the interrater reliability of the Star Excursion Balance Test. A total of 29 participants (19 women and 10 males) from the University Toledo and the University of Sydney volunteered for the study (Gribble et al., 2013). Participants were evaluated by five raters at two testing sites, performing four practice trials, with each rater assessing them for three test trials (Gribble et al., 2013). Each participant performed a modified SEBT including only the anterior, posterior medial, and posterior lateral reaching directions (Gribble et al., 2013). Additionally, the results from the three directions were averaged to create a composite non-normalized score, resulting in four dependent variables (Gribble et al., 2013). The four dependent variables were then divided into normalized (to leg length) and non-normalized reaching distances (Gribble et al., 2013). The three trials and composite were analyzed producing mean and maximum values, generating a total of 16 variables (Gribble et al., 2013). For the 16 measures, the interrater reliability was excellent for the normalized maximum excursion distances; the ICC ranged from 0.86 and 0.92 (Gribble et al., 2013). Reliability for non-normalized measures was stronger, ranging from 0.89 to 0.94 (Gribble et al., 2013). The interrater reliability of the leg-length measurement was excellent, with the ICC ranging from 0.86 and 0.96 (Gribble et al., 2013). For all these results a 95% confidence interval was used (Gribble et al., 2013). These results show that the SEBT is a reliable test when used across multiple raters in different settings, making it a quality tool for assessing dynamic balance, and is a suitable and inexpensive tool in clinical settings. Repeated testing using the SEBT is reliable after four trials are implemented to effectively account for the learning effect associated with the test (Gribble et al., 2013). The intra-rater reliability of the SEBT is excellent, which is repeated measurements by the same rater or researcher (Gribble et al., 2013).

Hyong and Kim (2014) analyzed and compared the intrarater and interrater reliability of the SEBT. The study involved 67 subjects (49 females and 18 males), who had no musculoskeletal injuries or neurological problems that would negatively influence dynamic balance (Hyong & Kim, 2014). All the subjects performed three trials of the SEBT, after having 6 practice trials (Hyong & Kim, 2014). For intrarater reliability, for all the directions, ICC values ranged from .88 to .96, SEM values ranged from 2.41 to 3.3, and SDD values ranged from 3.19 to 4.26 (Hyong & Kim, 2014). The results for the interrater reliability showed values for ICC ranging from .83 to .93, SEM ranged from 3.19 to 4.26, and SDD values ranged from 8.85 to 11.82 (Hyong & Kim, 2014). This shows that the SEBT is a highly reliable tool for measuring dynamic balance, and measurements for the intrarater reliability are even more reliable than those of interrater reliability (Hyong & Kim, 2014).

Use of Star Excursion Balance Test (SEBT)

Nearly one million students participate in high school basketball, with an estimate that 23% of these players sustain injuries and over 65% of these injuries occur in the lower extremity (Plisky, Rauh, Kaminski, & Underwood, 2006). Neuromuscular control may be the most modifiable risk factor in the prevention of knee and ankle injuries (Plisky et al., 2006). The major neuromuscular control elements identified include dynamic lower extremity alignment upon landing from a jump, shock absorption of peak landing forces, muscle recruitment patterns, and postural stability (balance) (Plisky et al., 2006). Plisky and colleagues (2006) used the SEBT as a predictor of lower extremity injury in high school basketball players. The study followed boys and girls basketball teams at seven Indiana high schools during the 2004-2005 seasons (Plisky et al., 2006). All subjects were baseline measured using the SEBT prior to the season for both limbs (Plisky et al., 2006). Throughout the season, the team athletic trainers documented any injuries that required time loss (Plisky et al., 2006). The results showed that players with an anterior right/left reach difference greater than 4 cm were 2.5 times more likely to sustain a lower extremity injury, with ideal results being comparable bilaterally (Plisky et al., 2006). Girls with a reach distance less than 94% of their limb length were 6.5 times more likely to have a lower extremity injury (Plisky et al., 2006). These results indicate that the SEBT is a reliable and predictive measure of lower extremity injuries in high school basketball players, also suggesting that SEBT can be incorporated into pre-participation physical examinations to identify players with an increased risk of injury (Plisky et al., 2006).

Various balance and other sensorimotor deficits have been associated with ankle instability, and consistently in literature, people with acute ankle instability and chronic ankle instability perform worse on the SEBT than people that are uninjured (Gribble et al., 2012). The SEBT has been widely used in research and in clinical practice to examine numerous topics, such as acute and chronic ankle instability, and balance (Munro & Herrington, 2010). The SEBT is a closed kinetic chain exercise, which mimics the single leg squat exercise, and therefore the stance leg requires strength, proprioception, neuromuscular control and adequate range of motion at the hip, knee and ankle joints to keep ones balance (Munro et al., 2010).

Olmsted et al. (2002) investigated the efficacy of the SEBT in detecting reach deficits in subjects with unilateral chronic ankle instability (CAI). Forty (20 CAI and 20 uninjured) subjects were recruited from a NCAA Division III University (Olmsted et al., 2002). All subjects completed six practice trials of the SEBT, and then rode for 5 minutes on a stationary bike, self-paced, followed by stretching before testing (Olmsted et al., 2002). Once this warm-up was completed, the participants completed three trials of the SEBT for each leg, taking the average of the three reach distances for all eight directions (Olmsted et al., 2002). The participants with CAI showed significantly lower reach distance scores with the injured leg compared to the same leg for the uninjured group (78.6 cm versus 82.8 cm) (Olmsted et al., 2002). When comparing the injured leg with the non-injured leg within the CAI group, the injured leg also showed significantly lower reach distances (78.6 versus 81.2) (Olmsted et al., 2002). This study suggests that the SEBT appears to be an effective way in identifying functional deficits in subjects with unilateral CAI through the measures of lower extremity reach distances (Olmsted et al., 2002).

Superior balance is the result of training experiences that influence an individual's ability to attend to relevant proprioceptive and visual cues (Bressel et al., 2007). Each sport requires different levels of sensorimotor processes to perform skills and protect the neuromuscular system from injury (Bressel et al., 2007). Bressel et al. (2007) compared static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. Thirty-four student-athletes from three different sports (11 soccer, 11 basketball, and 12 gymnastics) participated in the study; subjects were excluded if they had any lower extremity injuries, vestibular problems, visual problems, or a concussion (Bressel et al., 2007). All subjects were randomly assigned to complete both the Balance Error Scoring System (BESS) test, a static balance test, and the Start Excursion Balance Test (SEBT), a dynamic balance test (Bressel et al., 2007). For the BESS test, a lower score indicates better balance, whereas for the SEBT a higher score is indicative of better balance. The results of the study showed that the gymnastics group had the best balance during the BESS test, showing the lowest scores, followed by soccer and then the basketball group having the worst static balance of the three groups (Bressel et al., 2007). Looking at the SEBT, the soccer groups had the best balance with the highest scores, followed by the gymnastics group and the basketball group having the worst dynamic balance during the SEBT (Bressel et al., 2007). For the BESS the gymnastics groups had a 55% lower score on the BESS test than the basketball groups, and the SEBT scores were 7% higher in the soccer group than the basketball group (Bressel et al., 2007). These results suggest that dynamic balance is a better instrument to assess balance in athletes compared to static, as dynamic balance is a more realistic and practical measure due to simulating more game like situations of balance than that of static balance (Bressel et al., 2007). The SEBT offers a simple, reliable, low cost alternative to more sophisticated instrumented methods, such as the SportKAT3000, a machine that measures dynamic balance, and provides a more accurate assessment of lower extremity function than tests involving static balance (Olmsted et al., 2002).

Kinesio Tape and Pain

Since the SEBT is a reliable and valid test to use during the proposed study, the next step was looking at research on kinesio tape and all its possible uses, first starting with its claim of treating pain. Pain is a multidimensional experience that is caused from many musculoskeletal disorders (Gonzales-Enciso, 2009). Pain is subjective in nature, but is a highly relevant complaint (Gonzales-Enciso, 2009). The proposed mechanism for the relief of pain from KT is through the stimulation of sensory pathways in the nervous system, thus increasing afferent feedback (Williams et al., 2012). This is thought to diminish the input from nerves conducting nociception (pain) signals due to the gate control theory (Williams et al., 2012). These afferent (sensory) nerves inhibit the effects of the pain nerves, closing the "gates" to painful input, which prevents pain sensation from traveling to the central nervous system (Prentice, 2009). Therefore, stimulation of the sensory nerves is able to suppress pain (Prentice, 2009). This concept of sensory stimulation for pain relief, as proposed by the gate control theory, has empirical support (Prentice, 2009). Rubbing a contusion, applying heat, or massaging sore muscles decreases the perception of pain (Prentice, 2009).

Low back pain is one of the most common locations of symptoms, being caused by many factors, with 90% of them caused by benign and self-limited causes such as joint injuries (arthritis or intervertebral disk degradation) or soft tissue disorders (muscular or ligament injuries) (Gonzales-Enciso, 2009). These injuries are usually caused by a loss in bone strength, elasticity and muscular tone, and are more common as we get older (Gonzales-Enciso, 2009). Gonzales-Enciso (2009) investigated the effects of kinesio tape to improve functionality and relieve pain of people with non-specific low back pain. One hundred and twenty-two subjects volunteered for the study, but due to a long list of exclusion criteria, only 14 were suitable to participate in the study (Gonzales-Enciso, 2009). The 14 subjects were randomly split into two groups: a kinesio tape and therapeutic exercise group (Gonzales-Enciso, 2009). All participants were baseline tested using three assessment tools, including the Quebec Back Pain Disablity

Scale, Oswestry Low Back Pain Disability Questionnaire, and the Roland Disability Questionnaire (Gonzales-Enciso, 2009). After the first session of assessment tools were given, the kinesio tape was applied to the low back and the therapeutic exercise group was given exercises to complete until the next session (Gonzales-Enciso, 2009). A physiotherapist explained the exercises for two days to the participants to ensure that they understood and reproduced the exercises correctly, although the study never said what the exercises were (Gonzales-Enciso, 2009). The second session was five to seven days later, where another round of tape was applied and more exercises were given (Gonzales-Enciso, 2009). The third session was another five to seven days later, applying another round of kinesio tape to the low back of the patients and more exercises to the other group (Gonzales-Enciso, 2009). In the fourth and last session, all participants filled out the three assessment tools (Gonzales-Enciso, 2009). By the end of the study, only four participants from each group, a total of eight, finished the study due to being excluded for missing sessions or not performing the process correctly (Gonzales-Enciso, 2009). The results showed that there was a significant improvement in low back pain and disability when treating the patient with exercise therapy (Gonzales-Enciso, 2009). The results for the kinesio tape group showed no significant benefits were found for pain or disability, suggesting that exercise therapy should be used over kinesio tape when treating non-specific low back pain (Gonzales-Enciso, 2009). Only eight subjects completed this study however, so this small sample size may skew the results of the study, showing these results may not apply to the general population without further research with more subjects (Gonzales-Enciso, 2009).

Shoulder pain is a very common musculoskeletal complaint; lifetime prevalence of shoulder pain has been reported to range from 7-36% of the population, with rotator cuff pathology and subacromial impingement among the most common diagnoses made in the shoulder region (Thelen, Dauber, & Stoneman, 2008). Thelen et al. (2008) explored the efficacy of kinesio tape for shoulder pain. This study involved 42 subjects clinically diagnosed with rotator cuff tendinitis/impingement who were randomly assigned to one of two conditions: kinesio tape or placebo tape groups (Thelen et al., 2008). Three outcome measures, including Shoulder Pain and Disability Index (SPADI), pain free active range of motion (ROM), and a 100 mm visual analogue scale (VAS) to assess pain intensity at the endpoint of pain free active range of motion, were used (Thelen et al., 2008). All these measurements were taken at baseline, immediately after the application of the tape, three days and six days after tape application (Thelen et al., 2008).

The results from the study showed that the kinesio tape group had immediate improvement in pain free shoulder abduction (Thelen et al., 2008). However, no other differences between groups regarding pain, ROM, or disability at any time interval during the study was found (Thelen et al., 2008). This suggests that when kinesio tape is applied to patients with rotator cuff tendonitis/ impingement, it may result in immediate improvement in pain free shoulder abduction, but appears to not be more effective than the placebo at decreasing shoulder pain intensity or disability (Thelen et al., 2008).

Knee pain is also a common musculoskeletal complaint affecting approximately 25% of adults who comprise a significant percentage of patients seeking medical attention (Campolo, Babu, Dmochowska, Scariah, & Varughese, 2013). Campolo et al. (2013) compared two taping techniques (kinesio and McConnell), and investigated their effect on anterior knee pain during functional activities. A total of 20 subjects with anterior knee pain, ages 13 to 20 years, participated (Campolo et al., 2013). All subjects participated in two functional activities: a squat lift while lifting a weighted box (10% of body weight, plus 8.5 pounds), along with ascending and descending three flights of stairs (16 stairs per flight) (Campolo et al., 2013). These conditions were all done under three conditions: no tape, kinesio tape, and McConnell tape (Campolo et al., 2013). Each subject was asked to provide a pain level, using the 0-10 Numeric Pain Intensity Scale (NPIS), before and during the functional activities (Campolo et al., 2013). Results showed that no significant differences in pain were found between the three conditions in the functional squat, but the kinesio tape and McConnell tapes had a significant pain decrease compared to the no tape condition during the stair climbing activity (Campolo et al., 2013). This demonstrates that the KT and the McConnell tape were both effective in reducing pain during the stair climbing activities compared to the no tape condition, but did not show which was better between the two (Campolo et al., 2013).

With no studies to date examining the effects of KT during a sport competition, Merino-Marban, Fernandez-Rodriguez and Mayorga-Vega (2014) examined the effect of KT application immediately before and after a duathlon competition on calf pain and extensibility in duathletes. Thirty-four duathlete volunteers (6 females and 28 males) were recruited; none reported any musculoskeletal disorders at the time of testing (Merino-Marban et al., 2014). A Numerical Pain Rating Scale (NPRS) was used, and ankle range of motion (ROM) was recorded at baseline, immediately after taping application, and 10 to15 minutes after finishing the duathlon competition (Merino-Marban et al., 2014). The KT was applied on the calf of the duathletes 20 to 90 minutes before the race, and only applied to one leg of every participant while the other leg acted as a control (Merino-Marban et al., 2014). The results in the leg differences on ankle ROM values did not show a statistically significantly difference, whereas the leg differences for NPRS values showed statistical differences in decreasing pain for the taped leg (Merino-Marban et al., 2014). According to these results, the application of KT does not seem to affect calf extensibility either immediately before or after a competition among duathletes (Merino-Marban et al., 2014). However, the results suggest that KT application may reduce calf pain produced by a duathlon competition (Merino-Marban et al., 2014).

Kinesio Tape and Soft Tissue

Myofasical pain is a chronic soft tissue pain, that puts pressure on sensitive points in your muscles (trigger points) and causes pain in seemingly unrelated parts of the body, called referred pain (Garcia-Muro, Rodriquez-Fernández, & Herrero-de-Lucas, 2010). Myofasical pain is treated through a variety of manual therapy techniques including stretching, injections, compression, dry needling and massage (Garcia-Muro et al., 2010). Garcia-Muro et al. (2010) studied the effects of kinesio tape as a therapeutic procedure for the treatment of a patient with shoulder pain of myofascial origin. A 20-year old female with right shoulder pain of two days duration from myofascial trigger points was used for this case study (Garcia-Muro et al., 2010). The first two days the subject had been taking NSAIDS (ibuprofen) and using transcutaneous electrical nerve stimulation (TENS) to treat the pain, but had no improvements in pain (Garcia-Muro et al., 2010). The participant was baseline measured in a Visual Analogic Scale (VAS) for pain, active and passive range of motion (ROM), and functional tests including the Jobe's and Apley's tests (Garcia-Muro et al., 2010). Kinesio tape was then applied to the deltoid following Kase's protocol for myofasical trigger points (Garcia-Muro et al., 2010). Once applied, the subject was assessed for VAS, active and passive ROM, and the function tests again immediately after application of the kinesio tape, and two days after treatment when it was still on (Garcia-Muro et al., 2010). Results indicated that immediately after the application there was significant improvements in the patient's shoulder ROM and in the functional tests, but showed no changes in pain (Garcia-Muro et al., 2010). During the final assessment two days later, the patient continued to show improvements in shoulder ROM and in the functional tests, and this time the patient showed improvements in pain relief (Garcia-Muro et al., 2010). Data on pain, joint motion and shoulder function from this study may suggest that treatment with kinesio pain contributed to the resolution of the myofasical trigger points, with an immediate improvement and resolving the problem completely within a few days (Garcia-Muro et al., 2010).

Probably one of the most interesting uses of kinesio tape is its use on hypertrophic scars, keloids and scar contractures (Karwacinska et al., 2012). Karwacinska and colleagues (2012) explored the effectiveness of kinesio taping applications in managing hypertrophic scars, keloids and scar contractures. The studied involved 54 children, aged 2-18 years, with hypertrophic scars, keloids and scar contractures (Karwacinska et al., 2012). Kinesio tape was applied to all the subjects for 12 weeks, reapplying on average every seven days, with application techniques depending on the scar type, size and existing disorders of muscle and fasciae (Karwacinska et al., 2012). The stretch on the kinesio tape ranged from 25-100% depending on the individual's condition (Karwacinska et al., 2012). The effectiveness of the kinesio tape was verified every three weeks with a subjective evaluation, a questionnaire and the elevation of the scar was measured using a digital caliper (Karwacinska et al., 2012). The kinesio tape application caused changes in the appearance and perception of the scars in 37 patients after three weeks, ten more patients noticed such changes after six weeks, an additional five subjects after nine weeks, and the final two subjects after 12 weeks of application (Karwacinska et al., 2012). On the basis of researcher observations, questionnaire results and measurements, kinesio tape appears to be effective in the treatment of hypertrophic scars, keloids and scar contractures in a relatively short period of time (Karwacinska et al., 2012).

Delayed onset muscle soreness (DOMS) is defined as muscle injury caused by movements people are unaccustomed to, as a result of intensive physical activity (Lee, Bae, Hwang, & Kim, 2015). DOMS is usually experienced within 12 hours from the intensive activity, with the pain reaching a maximum in the following 48 to 72 hours (Lee et al., 2015). Eccentric exercises are more likely to induce DOMS, movements which are rarely used in daily activities (Lee et al., 2015). DOMS causes limitations of range of motion (ROM), swelling, reduced muscle strength, increased muscle thickness, and limited functional movement (Lee et al., 2015). Lee et al (2015) investigated the effects of kinesio taping (KT) on muscle function and pain due to delayed onset muscle soreness of the biceps brachii (Lee et al., 2015). Thirty-seven subjects with induced DOMS were randomized into either group 1 (control, n=19) or group 2 (KT, n=18) (Lee et al., 2015). Subjective pain using a visual analogue scale (VAS), ultrasonography to determine muscle thickness, maximal voluntary isometric contraction (MVIC), and electromyography were all recorded during the study (Lee et al., 2015). Measurements were recorded before the intervention (no KT tape on), and at 24, 48, and 72 hours after the intervention (tape still on) (Lee et al., 2015). Results in both groups 1 and 2 showed increases in muscle thickness at 24 and 48 hours, but at the 72-hour interval, group 2 (KT) showed a muscle thickness that was similar to the measurements obtained before induced DOMS, while group 1 did not (Lee et al., 2015). For muscle function, group 2 showed decreases in MVIC at 24 and 48 hour intervals, although MVIC recovered by 72 hours (Lee et al., 2015). Group 1 showed significant decreases for MVIC at all hour intervals (Lee et al., 2015). Both groups showed increased pain levels 24 after the interventions, reaching a maximum at 48 hours, and decreasing at the 72 hour mark (Lee et al., 2015). The pain levels were not significantly different between groups (Lee et al., 2015). This study suggests that applying KT to adults with DOMS may be an effective and faster method for recovery (Lee et al., 2015).

Kinesio Tape and Circulation

In addition to kinesio tape's effects on soft tissue conditions, kinesio tape is also proposed to help with circulation. Kinesio taping has been theorized to lift the skin from the underlying fascia, increasing blood and lymphatic flow, which might result in increased oxygen allotment to the muscle, decreasing inflammation, and improved anaerobic muscle function (Stedge, Kroskie, & Docherty, 2012). Theoretically, if KT enhances oxygen allotment via increased blood flow, the ability of the muscle to more rapidly perform oxidative metabolism would improve and subsequently would lead to better function of the muscle (Stedge et al., 2012). Improved blood flow also might affect muscle circumference and volume (Stedge et al., 2012). Volumetric and circumference measurements of the leg have been conducted as a representation of muscle mass and function (Stedge et al., 2012). Athletes with greater volume measurements have been identified as having increased muscle power and strength (Stedge et al., 2012). With all these questions Stedge, Kroskie, and Docherty (2012) investigated the effect of KT on the endurance ratio of the gastrocnemius muscle, along with the effect on blood flow, circumference and volumes measures of the gastrocnemius (Stedge et al., 2012). Sixty-one healthy, active people (23 men and 38 women) participated in the randomized controlled study, assigned to only one of three groups: KT, Sham KT, and control (Stedge et al., 2012). All volunteers participated in four days of testing; day one was paperwork, with day two being baseline measurements of blood flow, circumference, volumetric water displacement and endurance ratio using the isokinetic dynamometer, followed by application of the treatment (Stedge et al., 2012). On days 3 and 4 measurements of blood flow, circumference, volumetric water displacement and endurance ratio were taken after the application of the KT, Sham KT, or no tape groups (Stedge et al., 2012). Subjects did not participate in physical activity until the conclusion of the study, other than regular daily activities (Stedge et al., 2012). Results showed that KT had no effect on the endurance ratio, circulation to the muscle, as measured by blood blow, circumference and volumetric water displacement; and based on the results these subjects did not enhance muscle performance (Stedge et al., 2012).

De Quervain's disease is a disorder that is characterized by a large amount of edema over the radial side of the wrist, causing poor circulation, pain and tenderness (Homayouni, Zeynali, & Mainehsaz, 2013). Treatments for de Quervain's syndrome include rest, physical therapy (PT) modalities, analgesics, a thumb spica splint, corticosteroid injection and surgery (Homayouni et al., 2013). Corticosteroid injection is helpful in decreasing swelling and pain in about 80% of patients, but its adverse effects such as atrophy, hypo pigmentation and tendon rupture limit its functions (Homayouni et al., 2013). Kinesio tape is suggested as a new treatment of this disease (Homayouni et al., 2013). Homayouni et al. (2013) compared the effects of KT application on reducing pain and swelling in subjects with de Quervain's disease with standard PT modalities. Sixty patients, ages 18 to 65 years, and with more than four weeks having de Quervain's disease participated in the study (Homayouni et al., 2013). Patients were randomly split into two groups:

30 into the PT group and 30 into the KT group (Homayouni et al., 2013). In the KT group, three pieces of KT placed over the radial side of the wrist was used for four times weekly, and in the PT group ten minutes of paraffin bath, five minutes of ultrasound (US) underwater, transcutaneous electrical nerve stimulation (TENS), and a friction massage was applied every 3 days for 10 sessions. Pain severity was questioned with 100-mm visual analog scale (VAS), and the presence or absence of swelling was based on physician inspection and palpation (Homayouni et al., 2013). All measures were obtained at baseline and a month later at the end of the course of treatment (Homayouni et al., 2013). Results showed that in the KT group, 23 patients had wrist swelling and all of them complained about wrist pain at baseline, and after treatment all patients had significant pain reduction and swelling improved in 17 patients (Homayouni et al., 2013). In the PT group, all participants had wrist pain, and 26 people had wrist swelling at baseline and after treatment only five patients had significant swelling improvements, with six patients not having any significant improvements in pain reduction (Homayouni et al., 2013). Swelling improvement was significantly greater in the KT group but not in the PT group (Homayouni et al., 2013). This study indicated that the success rate of the KT group (80%) was significantly greater than the PT group (30%) for improving pain and swelling in patients with de Quervain's syndrome (Homayouni et al., 2013).

Although there aren't any studies out there to date to the researcher's knowledge, kinesio tape also claims that it helps with bruising (Kase, 2003). The theory is that the tape lifts the skin away from the area allowing for better blood flow and draining (Kase, 2003). Kase (2003) has a corrective technique called a circulatory/lymphatic correction that helps provide a directional pull of the tape to guide the exudate to less congested areas, through superficial tissues. This in turn helps to reduce symptoms due to inflammation and/or swelling (Kase, 2003). When the tails of the circulatory/lymphatic correction are overlapped, multi-directional changes of tension occur in the soft tissue as a person moves, and helps encourage the opening and closing of the initial lymphatics (Kase, 2003). The multi-directional change in tension also encourages the pumping of the valves of the collector lymphatics and encourages the uptake of fluid through the valves of deeper lymphatics (Kase, 2003). The lymphatic system is an overflow control system that works in conjunction with the venous system to control fluid movement back to the heart (Kase, 2003). The lymphatic system assists the venous system when it is over-extended (Kase, 2003). This is when there is too much internal venous pressure causing swelling in the interstitial space or when there is trauma to the soft tissue causing pain and/or swelling (Kase, 2003).

The circulatory/lymphatic correction taping technique can be used for acute and chronic swelling and inflammatory conditions (Kase, 2003). The anchor is placed in a less congested area that is free from swelling and the therapeutic direct of pull is toward the anchor (Kase, 2003). The anchor is typically positioned proximal toward the trunk area (Kase, 2003). The tails are positioned over the congested area, distal to the anchor, where the fluid is routed from the tails to the anchor area (Kase, 2003). The less congested area can then assist the congested swollen areas in the routing fluid back to the body, decreasing swelling and inflammation (Kase, 2003). Ultimately, this circulatory/lymphatic correction technique can enhance fluid exchange between layers of the skin, reduce edema, equalize inflamed soft tissue temperature, remove congestion of lymphatic fluid and hemorrhages under the skin, promote natural fluid flow between layers of soft tissue, reduce pain and discomfort, and promote soft tissue healing (Kase, 2003). The researcher of the proposed study, a Certified Athletic Trainer, has seen this personally in the athletic setting. Athletic Trainers use this technique a lot after an ankle sprain where there is a lot of swelling, or after an athlete sustains a bruise. After the application of kinesio tape for a few days, positive outcomes of reduced swelling and bruising over the areas that the tape was applied can be observed.

Kinesio Tape and Range of Motion

Along with the treatment of circulation, kinesio tape is said to increase range of motion (ROM). The two proposed mechanisms for the effect of KT on increased range of motion are the increased blood circulation in the taped area, and through KT providing sensory feedback that reduces fear of movement and thus increases range of motion (Williams et al., 2012). Low back pain has a prevalence of 80% in the general population, in which 50% of those will recover spontaneously within two weeks and 90% within six weeks (Lemos, Albino, Matheus, & Barbosa, 2014). KT technique uses a tape with unique qualities and the physiological applications include improving range of motion and decreasing pain (Lemos et al., 2014). With these implications, Lemos et al. (2014) investigated the effects of kinesio taping in forward bending of the lumbar spine. This study was a randomized clinical trial, with 39 participants divided into three groups: control, kinesio tape without tension (KWT), and kinesio tape for fascia correction (KFC) (Lemo et al., 2014). Lumbar flexibility was evaluated by the Schober test, marking the midpoint of the two posterior superior iliac spines and then two other points 5 cm below and 10 cm above the initial level (Lemo et al., 2014). The distance between the three points were measured in the standing position, then subjects were asked to bend forward, re-measuring the three points (Lemo et al., 2014). The difference between the lowest point and the highest point is an indication of the magnitude of flexion that occurs in the lower back, with normal lumbar mobility being at least a 5 cm increase when compared to the standing position (Lemo et al., 2014). Fingertip-to-floor distance consisted of measuring the distance from the distal end of the third finger to the ground when the patients flexed their trunk forward (Lemo et al., 2014). The subject was considered within normal flexibility for the test when the third finger was able to touch the ground (Lemo et al., 2014). The two tape conditions left the KT in place for 48 hours and were reassessed for Schober and finger-tip-to-floor tests at 24 hours with the tape on, 48 hours with the tape on, and 30 days after the tape was removed (Lemo et al., 2014). No information was given about what subjects were allowed and weren't allowed to do during the study in between the interventions (Lemo et al., 2014). The results showed that all three groups had no significant differences with the Schober test during any of the time interventions, but it was possible to observe an increase in lumber flexion after 30 days (Lemo et al., 2014). With the finger-to-floor distance assessment, the two groups, KFC and KTW, showed significantly improved flexibility after 24 hours and 48 hours (Lemo et al., 2014). The conclusion of this study is that kinesio taping influenced fascia mobility, allowing for slight improvement of lumber flexibility (Lemo et al., 2014).

Yoshida and Kahanov (2007) previously investigated the effects of kinesio tape on lower trunk range of motions. However, this study by Yoshida and Kahanov (2007) measured not only the trunk flexion but also looked at extension and lateral flexion range of motion. Thirty healthy subjects (15 females and 15 males) voluntarily participated in the study; subjects were excluded if they had any lower trunk injury or pain six months prior to the testing (Yoshida & Kahanov, 2007). Trunk range of motion was recorded before and after the application of kineiso tape or no tape (Yoshida & Kahanov, 2007). The measurement of flexion was done standing on a stool with heels together and knees straight (Yoshida & Kahanov, 2007). The subjects bent forward as far as they could, and the distance between the middle finger and the floor was measured (Yoshida & Kahanov, 2007). Extension was measured by standing straight up, marking the C7 spinous process and a imaginary line between right and left posterior superior iliac spine and marking the middle (Yoshida & Kahanov, 2007). The subjects extended the back and the differences between the two points were measured (Yoshida & Kahanov, 2007). For lateral flexion, the subjects stood straight up, keeping knees and ankles together and the elbows and wrists straight (Yoshida & Kahanov, 2007). The participants bent laterally to both sides with the distance between the middle finger and the floor being measured (Yoshida & Kahanov, 2007). The kinesio tape was applied using the Y technique, the base of the Y being placed over the middle of the sacrum, with the two sides of the Y following both sides of the erector spinae muscles (Yoshida & Kahanov, 2007). The results of the study showed significance in that the kinesio tape had 17 cm higher trunk flexion than the no tape condition, but showed no significant differences for lateral flexion and extension (Yoshida & Kahanov, 2007). The researchers suggest that kinesio tape using the Y flexion pattern may improve active range of motion in lower trunk flexion, but not for lateral flexion and extension (Yoshida & Kahanov, 2007).

Whiplash injuries or whiplash-associated disorders (WADs) often occur with motor vehicle accidents, as well as through sports (Gonzalez-Inglesias, Fernandez, Cleland, Huijebregts, & Gutierrez-Vega, 2009). This injury may result in bony or soft tissue injuries, which may lead to pain and loss of range of motion (Gonzalez-Inglesias et al., 2009). Gonzalez-Inglesias et al. (2009) compared the short-term effects of a kinesio taping application to the cervical spine versus placebo tape application on both neck pain and cervical range of motion in patients with acute WAD. Fifty-two patients reporting neck pain as a result of a motor vehicle accident within 40 days of the injury were screened for eligibility (Gonzalez-Inglesias et al., 2009). Participants were excluded if they had any previous diagnosis of migraine, previous whiplash, fibromyalgia, and litigation (Gonzalez-Inglesias et al., 2009). After the screening 41 patients were baseline measured for pain and range of motion (Gonzalez-Inglesias et al., 2009). These 41 volunteers were randomized and split into two groups: kinesio tape (experimental group), and placebo kinesio tape (sham group), with application to the cervical spine (Gonzalez-Inglesias et al., 2009). Once tape was applied, measurements of pain and range of motion were collected immediately after application, and 24 hours after application (Gonzalez-Inglesias et al., 2009). Results indicated that subjects receiving the KT experienced a greater decrease in pain immediately post application and at 24 hours follow-up compared to the placebo group, as well as a improvements in range of motion (Gonzalez-Inglesias et al., 2009). This suggests that individuals with WAD receiving an application of kinesio taping, applied with proper tension, exhibited statistically significant improvements immediately and 24 hours after application, but improvements in pain and cervical range of motion were small and may not be clinically meaningful (Gonzalez-Inglesias et al., 2009).

Kinesio tape is a treatment method shown to possibly improve joint range of motion (ROM) in the neck and lower back, but little investigation on the effects of KT on shoulder joint mobility have been done (Ujino et al., 2013). Ujino et al. (2013) investigated the effects of kinesio tape and stretching on shoulder ROM. A total of 71 healthy individuals with no history of shoulder injury participated in the study (Ujino et al., 2013). All subjects were baseline tested in internal (IR) and external rotation (ER) with a digital inclinometer, before they were placed into three intervention groups, including KT only, stretching only, and KT combined with stretching of the shoulder (Ujino et al., 2013). For the next three days, subjects in the stretch and KT/stretch groups performed a self-stretching program consisting of the sleeper stretch, doorway stretch, and cross body stretch once a day, with each stretch being performed three times for a 30-second hold and a 15-second relaxation period between stretches (Ujino et al., 2013). The overall results suggest that KT alone allowed a significant increase in shoulder ROM, and stretching was shown to have no effect on shoulder ROM, whether it was used alone or in combination with the KT (Ujino et al., 2013).

Kinesio Tape and Strength

Aside from KT affecting ROM, a lot of research has been done on the effects of KT on muscle strength. Medial elbow epicondylar tendinopathy (MET), also called golfer's elbow, is caused by repeated strain or overuse at the flexor-pronator mass (Chang et al., 2013). It is also a common disorder that occurs in overhead throwing, serving, hitting and racquet sports (Chang et al., 2013). Symptoms include pain at the origin of the wrist flexor, where it inserts into the medial epicondyle, and the inability to hold a racquet or make a fist (Chang et al., 2013). The prolonged symptoms and re-occurrences affect the athlete's grip strength and their performances, suggesting the need for stronger wrist flexors (Chang et al., 2013). Since KT has the chance of possibly increasing strength, this could be a possible intervention for athletes with MET. With this issue in mind, Chang et al. (2013) investigated the effectiveness of kinesio taping for athletes with MET. The study was a repeated measures design, with 27 male baseball players, all right hand dominant (Chang et al., 2013). They were divided into two groups: a healthy group (17) and a MET group (10), with each participant partaking in three conditions: without taping applied (WT), with placebo tape (PKT), and with kinesio tape applied (KT) on the forearm, allowing a 1-week interval between conditions (Chang et al., 2013). All subjects were assessed for maximal grip strength and grip force sense (absolute and related force sense) (Chang et al., 2013). Grip force sense was measured by using 50% of their maximal grip strength, called the target force; the participants were then asked to reproduce the target force to the best of their abilities (Chang et al., 2013). Results showed that KT had no influence on maximum grip strength, but indicated that both placebo KT and KT improved grip force sense immediately upon application on the forearm, in both the healthy and MET groups (Chang et al., 2013). This improvement in grip force sense immediately upon application suggests that this is due to increased proprioception in the forearm with the application of the placebo KT and KT groups (Chang et al., 2013). However, results indicate that KT tape may not have a significant practical function in helping with actual muscle strength (Chang et al., 2013).

Vitholka et al. (2010) investigated the effects of kinesio taping on quadriceps strength during concentric and eccentric isokinetic exercise in healthy non-athletic women. Twenty women were randomly selected to participate in the study, based on the following criteria: inactive prior to study, healthy without any knee pain or other muscular, or skeletal discomfort, and had a physical examination (Vitholka et al., 2010). Three different quadriceps taping modes were used (no tape, KT tape, and placebo tape) (Vitholka et al., 2010). Peak muscle torque of the dominant knee extensors was measured using an isokinetic dynamometer, including a bout of 5 concentric maximal knee extension/flexion repetitions at 60 and 240 degrees/seconds in the same order, separated by 2-minute rest intervals (Vitholka et al., 2010). Results showed that application of kinesio taping on the anterior surface of the thigh, in the direction of the vastus medialis, lateralis, and rectus femoris fascia, could increase the eccentric muscle strength (isokinetic eccentric peak torque), in healthy adults, but doesn't increase concentric muscle strength (Vitholka et al., 2010). The authors' explanation of this is that the direction of KT application has an influence on the muscle tone (Vitholka et al., 2010). Application of the tape from the muscles' origin to insertion is supportive, taking some of the load off the muscle and increases muscle strength, which is how the KT was applied during this study (Vitholka et al., 2010). Application from muscle insertion to its origin assists by relaxing the muscle tone (Vitholka et al., 2010).

A year later, Aktas and Baltaci (2011) investigated whether using a brace, KT, or both applications is more effective on knee muscular strength and functional performance. The study used twenty (11 females and 9 males) physically active university students, who had no lower extremity injuries within the past year (Aktas & Baltaci, 2011). Each subject partook in all four randomized trials wearing the knee brace, knee kineio tape, both or bare (control) (Aktas & Baltaci, 2011). Knee strength was measured using the isokinetic dynamometer; each subject performed a 5-minute warm-up, with testing being 10 repetitions at 180 degrees per second, a 1-minute break, followed by 5 repetitions at 60 degrees per second (Aktas & Baltaci, 2011). The functional performance consisted of a vertical jump and a one-leg hop test (Aktas & Baltaci, 2011). For the vertical jump and one leg tests, a standard measuring tape was used, each test being done three times with 1-minute rest intervals, and at the end the average of the three repetitions was used (Aktas & Baltaci, 2011). The overall findings suggested that KT was more effective in vertical jump performance and muscle strength when compared to the knee brace and the combination of knee brace plus KT (Aktas & Baltaci, 2011). The researchers theorized that these results are possibly due to KT increasing blood circulation in the taped area, and this physiological change may affect the muscle and myofasica, increasing strength, as well as possibly stimulating the cutaneous mechanoreceptors affecting the range of motion of the lower extremity (Aktas & Baltaci, 2011). The weight of the brace may have also affected the results during the tests by weighing the participants down more, causing the participants muscles to have to work harder, causing fatigue faster (Aktas & Baltaci, 2011). Braces can apply pressure to the skin and knee joint or stretch the skin, and this external load may inhibit cutaneous mechanoreceptors causing physiological changes on the joint and muscles, decreasing range of motion and strength (Aktas & Baltaci, 2011).

Fu et al. (2008) investigated the effects of kinesio taping on muscle strength in athletes. The study involved fourteen (7 males and 7 females) college athletes; subjects were excluded if they had any active knee pain, trauma in the lower limbs within the past three months, or if they had any surgeries to the lower limbs (Fu et al., 2008). Muscle peak torque and total work for both the quadriceps and hamstrings was measured using an isokinetic dynamometer (Fu et al., 2008). The subjects were measured at three different conditions including without tape (WT), immediately after taping (IT), and 12 hours after taping with the tape still intact (Fu et al., 2008). The KT was applied to the anterior aspect of the thigh, starting 10 cm distal to the anterior superior iliac spine, cut at the junction between the rectus femoris tendon and the patella, and being circled around the patella, ending at the inferior aspect of the patella (Fu et al., 2008). To avoid any muscle fatigue induced from the isokinetic assessments, there was at least seven days between assessments (Fu et al., 2008). At the end of all the testing, results showed no significant differences in the muscle peak force or total work at any of the three measured conditions.

suggesting that KT on the anterior thigh didn't increase or decrease muscle strength (Fu et al., 2008).

Another kinesio tape investigation on its effects on jumping performance was done in by Schiffer, Mollinger, Sperlich, and Memmert (2015). Eighteen healthy, elite, uninjured female track and field athletes with expertise in long jump, sprint and heptathlon participated (Schiffer et al., 2015). A double 1-legged jump test was performed before and after the application of kinesio tape on the gastrocnemius, hamstrings, rectus femoris, and iliopsoas muscles according to the generally accepted technique (Schiffer et al., 2015). A double 1-legged jump is explained by starting standing on one leg, then all participants performed two 1-legged jumps with the same leg into a long-jump pit filled with sand (Schiffer et al., 2015). Jump performance was defined as the distance between the starting point and nearest mark in the sand and was measured in meters (Schiffer et al., 2015). The findings of this study suggest that the application of KT has no influence on jumping performance in healthy, uninjured female elite athletes, showing no significant performance enhancement on jumping distance in the double 1-leg jump test (Schiffer et al., 2015).

Vertical jumping is a movement often seen in sports and exercise, being carried out by rapid extension of the hip, knee, and ankle joints, caused from a variety of muscles' actions (Huang et al., 2011). Vertical jump height performance can be improved through an increased muscle contraction force (Huang et al., 2011). In 2011, Huang et al. studied the effect of kinesio tape on muscle activity and vertical jump performance in healthy inactive adults (Huang et al., 2011). Thirty-one healthy adults (19 males and 12 females), ages 21 to 31 years, were recruited for the study; subjects were excluded if they had a history or spinal, hip, knee or foot pathology, any neurological impairment or a history of lower limb fractures (Huang et al., 2011). All participants were randomly assigned to one of three groups: no tape (control), elastic tape (KT), and non-elastic tape (placebo) (Huang et al., 2011). The tape techniques were in a Y-shape from the calf, originating at the bottom of the heel (calcaneous), the two heads of the Y- shaped tape was attached following along the soleus ending up on the medial and lateral heads of the gastrocnemius muscle (Huang et al., 2011). Before tape application, all participants performed three maximal vertical jumps, while measures of ground reaction force (GRF) using a force plate, and an electromyography (EMG) to measure muscle activity of the gastrocnemius, soleus and tibialis anterior were taken (Huang et al., 2011). After baseline measures, the tape applications were applied to the two intervention groups, and the control still had no tape (Huang et al., 2011). Once applied, all participants performed another three maximal vertical jumps with GRF and EMG being measured (Huang et al., 2011). The results showed that the EMG activity of the medial gastrocnemius and VGRF significantly increased when the kinesio tape was applied, but there was no significant differences in the vertical jump height (Huang et al., 2011). The results for the placebo tape showed no change in EMG activity of all muscles and VGRF, with a significant decrease in vertical jump height (Huang et al., 2011). Based on the results, it suggests that kinesio tape may benefit the medial gastrocnemius muscle strength and push-off force, causing an increase in vertical jump height (Huang et al., 2011).

Wong, Cheung, and Li (2012) explored the effects of isokinetic knee function in healthy subjects with and without kinesio taping. Thirty participants (14 males and 16 females) were recruited; subjects were excluded if they had any known musculoskeletal or cardiopulmonary conditions, as well as any active joint pain or related symptoms in the last year (Wong et al., 2012). All participants attended two isokinetic testing sessions, one of the sessions involved KT applied over the vastus medialis muscle, or without any KT applied; this was randomized with a coin flip, with the second session involving the condition that hadn't been done yet (Wong et al., 2012). The isokinetic testing involved maximal concentric knee extension and flexion using a isokinetic dynamometer, measuring peak torque, normalized total work done, and time to peak torque (Wong et al., 2012). Before testing, all subjects performed a 5-minute warm-up on a bike at low resistance, followed by one minute of rest before the testing (Wong et al., 2012). Participants then performed the testing at three different angle velocities: 60, 120, and 180 degrees per second, for ten repetitions, with 60 seconds rest in between each set (Wong et al., 2012). Results showed no significant differences in peak torque or normalized total work done for knee flexion and extension with and without KT, even at the three different angles (Wong et al., 2012). For time to peak torque, the KT application showed a shortened time for knee extension for all three angle velocities, but didn't show any differences in knee flexion for KT and without KT application (Wong et al., 2012). Overall, this investigation showed that the application of KT did not alter muscle peak torque generation and total work done, but may be able to shorten the time to generate peak torque (Wong et al., 2012).

Within the same year, Lins, Neto, Amorim, Marcedo, and Brasileiro (2012) explored the effects of kinesio tape on neuromuscular performance of the femoral quadriceps and lower limb function in healthy subjects. Sixty healthy female volunteers, ages 18 to 28 years, who had no medical issues participated in the study (Lins et al., 2012). All subjects warmed up on a stationary bike for five minutes, followed by being assessed in lower limb function, one-footed static balance, concentric and eccentric peak knee extensor torque and electromyographic activity of the vastus lateralis (Lins et al., 2012). The lower limb function consisted of maximal single and triple hop tests, measuring their maximum distance of two trials each test, and to normalize the data the height of each subject was incorporated (distance/height x 100) (Lins et al., 2012). A computerized baropodometer, a plantar pressure measuring system, was used to collect the one-foot static balance of each subject (Lins et al., 2012). An isokinetic dynamometer was used to measure knee extensor torque, with each subject performing 5 maximum concentric and eccentric knee extensor contractions at 60 degrees per second (Lins et al., 2012). The muscle activity of the vastus lateralis was measured using electromyography (EMG), looking at root mean square (RMS) during concentric and eccentric activity, as well as maximum voluntary isometric contraction (MVIC) (Lins et al., 2012). After baseline measures, the subjects were randomly split up into three groups of 20, including one group using KT, one group using the non-elastic placebo, and a no tape control group (Lins et al., 2012). The tape application for the KT and placebo groups was placed over the vastus medialis (VM), the vastus lateralis (VL), and the rectus femoris (RF) (Lins et al., 2012). After the applications of the KT or placebo, all subjects were tested again through the four conditions (Lins et al., 2012). At the end of the study, results showed no significant differences for the lower limb function and one-footed static balance among the three groups, as well as no significant differences in EMG activity and knee extensor torques (Lins et al., 2012). The results suggest that KT application to the RF, VL, and VM did not alter lower limb function, one-footed static balance, peak knee extension torque or activity of the VL muscle (Lins et al., 2012).

Kinesio tape and Joint Alignment

Along with kinesio tape being used for potentially increasing strength, changing joint alignment is a relatively new claim for kinesio tape (Aytar et al., 2011). For many years McConnell tape has been used for alignment, but with the new trend and increased popularity of kinesio tape, it has also been used and claimed to help with alignment (Aytar et al., 2011). One of the most common uses of tape for joint alignment is for patellofemoral pain. Patellofemoral pain syndrome (PFPS) is a common problem experienced by active adults and adolescents; studies have shown PFPS to be the single most common diagnosis among runners and in sports medicine (Aytar et al., 2011).

Aytar et al. (2011) looked at the initial effects of kinesio taping applied to the knee/patella for joint alignment on pain, strength, joint position sense and balance in patients with PFPS as compared to a placebo kinesio taping (PKT) application (Aytar et al., 2011). Twenty-two female subjects diagnosed with PFPS participated in the study, with subjects being randomized into two groups: KT group and PKT group (Aytar et al., 2011). Subjects were taped by a physical therapist certified to apply KT using two mechanical patellar correction techniques (Aytar et al., 2011). Outcome measurements were taken before and 45 minutes after the application (Aytar et al., 2011). Muscle strength was measured with an isokinetic dynamometer to evaluate quadriceps strength, at angular velocities of 60 and 180 degrees/second with 5 repetitions at each velocity, and a 30-second rest in between each set was allowed (Aytar et al., 2011). Using the same dynamometer, joint position sense was measured by blindfolding each subject to eliminate visual input, then subjects moved their knee from flexion to extension and stopping the dynamometer by pressing the abort button when subjects felt they were in the mid-position of the range (45 degrees) (Aytar et al., 2011). Static and dynamic balance were assessed by using the Kinesthetic Ability Trainer (KAT) 3000 (Aytar et al., 2011). A visual analog scale (VAS) was used to determine pain intensity of their present pain when walking, ascending and descending stairs (Aytar et al., 2011). Results showed significant improvements between strength of quadriceps at 60 and 180 degrees per second, and static and dynamic balance scores before and 45 minutes after the application of KT (Aytar et al., 2011). There were also significant improvements between strength of the quadriceps at 60 degrees per second and static balance scores before and 45 minutes after application of the PKT (Aytar et al., 2011). Thus, KT application does not seem to be an effective treatment for both decreasing pain and improving joint position sense for patients with PFPS (Aytar et al., 2011). Results indicate no significant differences between the PKT and KT groups in proprioception, pain, balance and muscle strength when a patellar joint alignment correction was applied (Aytar et al., 2011).

Although realignment of the patella was one of the proposed mechanisms to treat PFPS or anterior knee pain, it has been shown from radiographic, computerized axialtomography, structural MRI, and kinematic studies that tape does not significantly alter patellar mediolateral alignment (Callaghan, McKie, Ricardson, & Oldham, 2012). Callaghan et al. (2012) showed that there is an altered brain response when a simple taping technique is applied to the patella of individuals during a simple proprioception task, revealing a potentially non-biomechanical effect of patellar taping during active knee movement. The reduced pain and improvements in function for patella problems, is moving toward a more sensory stimulation and proprioception explanation, rather than actually changing the alignment of the patella (Callaghan et al., 2012).

Ankle Taping

Apart from kinesio tape being related to alignment, kinesio tape has been utilized during ankle taping potentially increasing proprioception, strength, stability and decreasing pain. The ankle is the most common injured joint in contact sports, indoor sports, team sports and sports with high frequency of jumping, such as rugby, soccer, volleyball, handball and basketball (Bicici, Karatas, & Baltaci, 2012). Ankle injuries can be defined as either acute or chronic, with ligamentous injury the most common acute diagnosis (Bicici et al., 2012). About 85% of all ankle injuries are ankle sprains involving the lateral ankle ligaments (Bicici et al., 2012). Chronic injuries are often related to, or are the sequel of, acute sprains, or overuse syndromes of the surrounding soft tissues (Bicici et al., 2012). Functional ankle instability (FAI) is seen in about 40% of all patients that sustain an ankle sprain, and is defined as a "disabling loss of reliable static and dynamic support of a joint" and a "tendency for the foot to give way" (Bicici et al., 2012). Taping and bracing is said to be an important part of the treatment of acute and chronic phases of an ankle injury, and many athletes believe that ankle support is important for their performance (Bicici et al., 2012). Functional performance effects of ankle taping and bracing have been assessed in both injured and un-injured subjects (Bicici et al., 2012). However, no consensus exists regarding whether ankle supports using various brace or tape designs interfere with normal function or not (Bicici et al., 2012).

In 2012, Bicici, Karatas, and Baltaci investigated the effects of different types of taping (KT, athletic tape, and placebo) on functional performance in athletes with chronic inversion ankle sprains. Fifteen male basketball players with chronic inversion ankles sprains between the ages of 18 to 22 years participated in the study (Bicici et al., 2012). Functional performance tests: hopping test, single limb hurdle test, standing heel rise test, vertical jump test, the star excursion balance test (SEBT) and kinesthetic ability trainer (KAT) were used to quantify agility, endurance, balance and coordination (Bicici et al., 2012). These tests were conducted four times at one-week intervals using varied conditions including the placebo tape, without tape, standard athletic tape and KT (Bicici et al., 2012). The study followed a randomized and crossover design (Bicici et al., 2012). Neither KT nor athletic tape had a significant effect on performance on the hopping test, the single limb hurdle, dynamic balance, and SEBT tests (Bicici et al., 2012). However, athletic taping caused a significant decrease in performance in vertical jump and standing heel rise tests, while KT did not limit functional performance on these tests (Bicici et al., 2012). Athletic tape restricts functional ROM, especially into plantar flexion, which could have contributed to the diminished vertical jumps and standing heel raises, whereas KT doesn't restrict ROM allowing for optimal performance (Bicici et al., 2012).

Ankle re-injury rates are known to be high, so it is important to identify specific injury prevention strategies, whether that be non-elastic or elastic tape (Briem et al., 2011). Non-elastic adhesive tape has been used for injury prevention and during rehabilitation after ankle injury, along with being shown to be effective in restraining ankle inversion, and its use may decrease ankle sprain (Briem et al., 2011). The tape is rigid, tears easy, doesn't stretch further than its original state, and is commonly known as athletic tape, or leukotape (Briem et al., 2011). In contast, elastic tape is very flexible, doesn't tear easy, thus needing scissors, can stretch up to 140% of its original length and is commonly known as kinesio tape or elaskiton (Briem et al., 2011). Due to the elastic properties, the ability of kinesio tape to enhance functional stability of the ankle relies on proprioception and muscle activation rather than mechanical support (Briem et al., 2011).

In 2011, Briem and colleagues investigated the effects of taping on the level of activation of the fibularis longus (peroneus) muscle during a sudden ankle inversion perturbation. The fibularis longus muscle is looked at due to its role as the primary everter and dynamic stabilizer of the ankle, and its function in relation to ankle stability and lateral sprains has been extensively studied (Briem et al., 2011). Forty-one healthy males were recruited from three premier league teams (soccer, basketball, and handball; any subjects with injury to the lower extremity six weeks prior to the study were excluded (Briem et al., 2011). Each participant was evaluated for both limbs using the Star Excursion Balance Test (SEBT), and the 15 individuals with the highest and the 15 individuals with the lowest scores were selected for further testing (Briem et al., 2011). These participants were tested under 3 conditions presented in random order, following a repeated measures design (Briem et al., 2011). The three conditions consisted of leukotape (non-elastic), kinesio tape (elastic), and a no tape group (Briem et al., 2011). The test consisted of participants standing on one foot on a balance board, as a 10 kg weight was dropped, creating an inversion perturbation of 15 degrees (Briem et al., 2011). A wireless electromyography system was hooked up to the fibularis longus muscles to measure muscle activity during the test, with peak muscle activity and time to peak being analyzed (Briem et al., 2011). Results indicated that significantly greater muscle activation was found when ankles were taped with non-elastic tape compared to no tape, with kinesio tape having no effect on muscle activity compared to no tape (Briem et al., 2011). These results suggest that ankle taping with non-elastic tape may enhance muscle activity of the fibularis longus, potentially enhancing dynamic support of the ankle (Briem et al., 2011). The efficacy of KT in preventing ankle sprains via the same mechanism is unlikely, as it had no effect on muscle activity of the fibularis longus (Briem et al., 2011).

Perception

Adhesive tape is a popular treatment modality for athletic injuries because it has many uses, including support, stability, and proprioception, and has been shown to decrease ankle sprain incidence by providing mechanical support and enhanced proprioception to the foot-ankle complex (Hunt & Short, 2006). For these reasons, tape continues to be one of the most commonly used interventions, yet the psychological effects of taping on athletes is not clearly understood (Hunt & Short, 2006). In 2006, Hunt and Short explored college athletes' perceptions of adhesive ankle taping. Eleven participants volunteered to be interviewed for this study, and were current athletes from five NCAA collegiate athletic teams (DII football, women's basketball and volleyball, and DI men's and women's ice hockey) (Hunt & Short, 2006). There were 5 males and 6 females between 18 and 23 years of age (Hunt & Short, 2006). The study was delimited to athletes who currently taped their ankles, and were randomly selected to one group: either recent injury using tape, past injury using tape, or no prior injury using tape (Hunt & Short, 2006). All subjects performed a semi-structured interview, which included a series of open-ended questions (Hunt & Short, 2006). At the end of all the interviews, athletes' perceptions of the tape indicated feelings of increased confidence, increased strength, and decreased anxiety for injury or re-injury (Hunt & Short, 2006) Taping has a psychological impact on these athletes, and the authors of this research suggest that health professionals should educate athletes about the uses and functions of adhesive tapes (Hunt & Short, 2006). Taping an ankle usually takes less than two minutes, and can have a profound positive impact on an athlete's psychological preparation (Hunt & Short, 2006).

Athletes often report a feeling of increased stability due to tape and/ or brace, however studies examining the effect of an ankle "appliance" on stability have produced conflicting results (Gear, Bookhout, & Solyntjes, 2011). Gear et al. (2011) examined the effects of ankle taping and bracing on dynamic balance and perception of stability. Twenty-one physically active subjects, with no lower extremity injury within the last 6 months and did not have any history of vestibular or balance disorders, were included in the study (Gear et al., 2011). A Biodex Balance System SD was used to measure each subject's overall stability, and dynamic balance was assessed in a single leg (stork) stance during three 20-second trials at stability level four, which allows for 20 degrees of platform tilt in all directions (Gear et al., 2011). Overall stability and perception of stability were performed barefoot, with the ankle taped, and braced (Gear et al., 2011). All subjects performed three practice sessions, then were randomly assigned to one of the three conditions; following a 15-minute rest period subjects performed the stability test in one of the three conditions assigned (Gear et al., 2011). After the test was completed, a 15-minute rest period was given before completion of the next stability test under the new condition (Gear et al., 2011). This procedure was repeated for a third stability test for the remaining condition (Gear et al., 2011). Perception of stability was assessed using a 4-point Likert scale following each test session (Gear et al., 2011). No significant differences between conditions were found for overall stability, although significant differences were found for the participants' perception of support (Gear et al., 2011). The ankle tape condition was significantly different from both the barefoot and braced condition, showing increased perception of stability (Gear et al., 2011). Results indicate that ankle taping and bracing do not affect overall dynamic balance. Participant perception of stability however, indicates that ankle tape might provide a false sense of increased stabilization of the ankle (Gear et al., 2011). The findings are in agreement with other studies (Hunt & Short, 2006; Sawkins et al., 2007) that ankle taping and bracing does not affect stability, but there may be a perception that tape provides increased stabilization of the ankle (Gear et al., 2011).

In 2010, Delahunt, McGrath, Doran, and Coughlan investigated the effects of taping on actual and perceived dynamic postural stability in persons with chronic ankle instability. Sixteen physically active participants (10 women and 6 men) volunteered for the study, and were excluded if they had less than 2 inversion ankle sprains or history of eversion or high ankle sprains (Delahunt et al., 2010). Three conditions were applied to the ankle: no tape, lateral subtalar sling, and fibular repositioning tape (Delahunt et al., 2010). Participants completed a modified Star Excursion Balance Test (SEBT) on the more unstable ankle (Delahunt et al., 2010). After each set of SEBT trials, for each tape condition, participants were questioned regarding their perceived levels of stability, confidence, and reassurance compared with their practice trials (no tape) (Delahunt et al., 2010). Results showed no statistically significant differences in reach distance among the 3 tape conditions on the SEBT (Delahunt et al., 2010). Perceived levels of confidence, how well the participant believed he/she would perform the SEBT, increased for 56% of participants under both taping conditions (Delahunt et al., 2010). Perceived levels of stability increased for 87.5% of participants using lateral subtalar taping and 75% using fibular repositioning (Delahunt et al., 2010). Reassurance that he/she would not sprain their ankle during the test increased for 68.75% and 50% of participants for subtalar and fibular repositioning, respectively (Delahunt et al., 2010). This study indicated that there was no significant difference in actual SEBT scores in any of the conditions; however participants had a significant increase in perceived stability, confidence, and reassurance for both taping conditions compared to the no tape condition (Delahunt et al., 2010).

Placebo Effect

The placebo effect is a favorable outcome arising purely from the perception or belief that one has received a beneficial treatment (Duncan et al., 2009). Duncan et al. (2009) investigated the placebo effect of caffeine on short-term resistance exercise to failure. Twelve males volunteered to participate in the study, all having experience performing resistance exercise and all were free of musculoskeletal pain or disorders (Duncan et al., 2009). The study used a within-subjects repeated measures design (Duncan et al., 2009). Each subject was informed they were participating in a study examining the impact of caffeine ingestion on resistance exercise performance (Duncan et al., 2009). They were all told that they would consume two solutions, presented in random order, one containing 3 mg/kg of body weight caffeine and one containing a placebo (Duncan et al., 2009). Each participant attended the performance laboratory on three occasions; the first visit was to determine each subject's 1-repetition maximum (1RM) for the single leg extension, and this was used to set the 60% 1RM for the subsequent trials (Duncan et al., 2009). The next two trials were randomized in order and separated by 24 to 72 hours, where the subjects were told they were going to take the caffeine supplement or the placebo diluted into a solution, followed by their exercise bout of 60% 1RM until failure (Duncan et al., 2009). The catch was that before their exercise bout, they were actually only given 250 mL of artificially sweetened drink (Duncan et al., 2009). The researchers found that there was a significant difference in the total repetitions completed; subjects completed more repetitions and had lower rates of perceived exertion (RPE) when they believed they had consumed caffeine compared with the control condition when they thought they had consumed a placebo (Duncan et al., 2009). However, no significant difference was found in systolic blood pressure, diastolic blood pressure, or peak heart rate across conditions (Duncan et al., 2009). This shows that when individuals consumed a substance that they believe to be caffeine, known to enhance performance, they completed more repetitions to failure and had a lower RPE than when they consumed a substance they believed to be a placebo (Duncan et al., 2009).

In 2007, McClung and Collins investigated the performance contribution made by expectancy alone compared with the performance enhancing effects of sodium bicarbonate on a 1,000-m running time trial. Sixteen endurance athletes were recruited for the study, and were required to pass a health questionnaire, have no previous consumption of sodium bicarbonate, needed to obtain national age-group entry standards within the previous year, and train at least 5 days per week (McClung & Collins, 2007). All 16 participants completed all four randomly assigned experimental conditions that included the following: told they would receive the supplement of sodium bicarbonate and actually did; told they would receive the supplement and didn't; told they wouldn't receive the supplement and actually did; and told they wouldn't receive the supplement and didn't (McClung & Collins, 2007). Between each condition there was a 6-day rest/wash-out period (McClung & Collins, 2007). All solutions of the supplements and placebos where administered in a 750 mL water bottle, and the amount of sodium bicarbonate used (when appropriate) was calculated as 0.3 g/kg of body mass (McClung &

Collins, 2007). Participants were given the solution two hours before the time trial run, and then twenty minutes before they ran they were asked to note their rate of perceived exertion, RPE (McClung & Collins, 2007). Five minutes before the run the heart rate monitors were fitted, followed by blood lactate readings recorded at one minute before the run (McClung & Collins, 2007). The heart rate monitor started recording data 30 seconds before the run (McClung & Collins, 2007). Then the 1,000 meter time trial was performed (McClung & Collins, 2007). Once the time trial was completed blood lactate and RPE was recorded, followed by a third blood lactate measure at 5 minutes after the run (McClung & Collins, 2007). Last, at 6 minutes after the time trial the heart rate recording was stopped and removed (McClung & Collins, 2007). The results showed that believing one had taken a supposedly beneficial substance resulted in times almost as fast as those associated with consuming the supplement itself, whereas taking the supplement without knowledge yielded no significant performance increase (McClung & Collins, 2007). These results further suggest that expectancy effects alone can generate increases in performance (McClung & Collins, 2007). The determining factor was associated with the athlete's belief in what they are being told or given; the RPE results clearly supported this because only the information offered (told) had any significant impact (McClung & Collins, 2007). Athletes apparently paid much more attention to what was being told or given than the actual messages sent by their muscles (McClung & Collins, 2007).

In 2007, Beedle, Coleman, and Foad investigated the positive and negative placebo effects resulting from the deceptive administration of an ergogenic aid. Forty-two sport team athletes (basketball, field hockey, netball, rugby, football, and soccer) agreed to participate in the study (Beedle et al., 2007). Subjects were randomly assigned to 1 of 2 groups: Group 1 (positive belief) and Group 2 (negative belief), and both groups were informed they would be completing a repeated sprint protocol in 2 conditions: baseline and experimental (Beedle et al., 2007). All subjects completed a 20-minute warm-up, followed by three 30-meter sprints with 2 minutes recovery between each (Beedle et al., 2007). Participants were then administered the "ergogenic aid", a red and green gelatin capsule with 200 mg of cornstarch in it (i.e., an inert substance) (Beedle et al., 2007). The positive belief group was told the pill had been found to enhance both repeat sprint and endurance performance in team sport players, whereas the negative belief groups were told that the pill enhanced endurance, while having a negative impact on repeat sprint performance (Beedle et al., 2007). The results showed that group 1's mean speed did not differ significantly from the baseline and experimental trials, but the significant linear trend of greater speed with the experimental trials suggest that the positive belief had a positive effect on performance; whereas the negative belief group ran 1.57% slower than the baseline, suggesting a negative belief had a negative effect on performance (Beedle et al., 2007). These results show that if subjects have a belief in the efficacy of a treatment, it might significantly influence the findings in experimental research (Beedle et al., 2007).

Ankle injuries are the most common injury in sports and recreational activities, accounting for up to 45% of all sporting injuries (Sawkins, Regshauge, Kilbreath, & Raymond, 2007). Ankle taping is the most common method for supporting the chronically unstable ankles, and it is the principle means of preventing ankle sprains (Sawkins et al., 2007). The two most common theories for why taping works are that the tape provides mechanical support or that it enhances proprioception (Sawkins et al., 2007). An alternative theory by which ankle taping may prevent injury is that if an athlete believes that taping will prevent injury, the athlete may participate with great confidence, thus the tape has a placebo effect (Sawkins et al., 2007). Sawkins et al. (2007) investigated whether there was a placebo effect with ankle taping in individuals with ankle instability, using a model in which the participants was exposed to the belief that the placebo tape would be effective. Thirty participants (11 males and 19 females) with ankle instability from previous ankle sprains volunteered for this study (Sawkins et al., 2007). Participants were excluded if they had a past history of fracture or surgery to the lower limb, ankle sprain within the last 3 weeks, pain or palpable effusion of the ankle at the time of testing, or neurological, visual, or any vestibular deficit (Sawkins et al., 2007). Participants were blinded to the true purpose of the study and were informed that the aim of the study was to compare two methods of ankle taping, referred to as mechanical (real) and proprioceptive (placebo) taping (Sawkins et al., 2007). Participants were tested under three conditions in random order: real (mechanical) tape, placebo (proprioceptive) tape, and control (no tape) (Sawkins et al., 2007). The mechanical (real) tape consisted of a technique that all athletic trainers use to prevent ankle sprains, whereas the proprioceptive (placebo) tape consisted of a single strip of tape approximately 10 cm long on the later aspect of the ankle (Sawkins et al., 2007). For each condition, participants completed two functional performance tests in random order: the hopping test and the modified star excursion balance test (SEBT), completing three trials of each test under each condition (Sawkins et al., 2007). After completion of each functional test under each condition, participants were questioned regarding their perceived level of stability, confidence, and reassurance when performing the test compared with the practice trials. Results showed that there were no significant differences in performance among the three conditions on the hopping test, as well as the modified star excursion balance test (Sawkins et al., 2007). Ankle tape, both real and placebo, did influence and improve participants' perceptions of stability, confidence, and reassurance when performing the functional tests (Sawkins et al., 2007). The real tape condition had a better effect on the greatest number of participants in terms of perceptions of stability, confidence, and reassurance (Sawkins et al., 2007). These results suggest that although the placebo tape does not influence performance on the functional tests studies, it did affect the way individuals feel when performing such tests, although less than real tape (Sawkins et al., 2007). Instilling in participants the belief that the tape would protect them from injury (i.e. the placebo effect) has potential to improve perception of stability, confidence, and reassurance when performing functional tasks (Sawkins et al., 2007).

Conclusion

Ankle sprains are the most common sports related injury, accounting for about fifteen percent of all injuries, which results in injured ligaments increasing their laxity, decreasing stability, and can alter or damage an individual's proprioception in the ankle. Poor postural balance has been linked with an increased risk of joint injury and muscle imbalances. Biomechanical misalignments have been shown to heighten ligament stress at the ankle, which also increase injury risk, and single leg balance training exercises are successful for prevention of lower extremity injuries. Kinesio tape is a relatively new trend in today's society and its use is a popular debate within many groups of health professionals. These professionals question whether kinesio tape is actually providing therapeutic benefits or if it is acting as a placebo. The recent research out there for the benefits of kineso tape, whether it is used for pain, realignment, muscle inhibiation or activation, improved proprioception, balance and/or stability are equivocal and warrant more research to clarify KT's efficacy, and possibly to back up its benefits or perceived claims.

Through this review of literature, the researcher was able to find 31 articles that involved kinesio tape, and of those 31 articles only 5 of them were on the ankle and only 2 involved balance. Of all the articles, only one article involved kinesio tape and its effects on chronic ankle instability in subjects while using the dynamic Star Excursion Balance Test (SEBT). Since no research has been done on ankle kinesio tape with healthy individuals and its effectiveness during the SEBT, this warrants further investigation. Ankle sprains are the most common injury in athletics, damaging the individual's proprioception and balance, decreasing stability and increasing laxity in the ankle. With the increased need for research on testing kinesio tape's claims that it is beneficial in the therapeutic setting, this was the basis of the current investigation.

Chapter 3: Methods

The purpose of this study was to investigate whether or not the application of kinesio tape to college Division II athletes' ankles would aid in dynamic balance using the Star Excursion Balance Test (SEBT). This research investigated the measurements of each reach distance from the SEBT while subjects participated in three different conditions administered randomly: no tape, kinesio tape, and placebo tape. A questionnaire was used to examine the perceptions of the athletes related to kinesio tape's effectiveness (Appendix E). This investigation used quantitative and qualitative methods to investigate these research questions.

Setting

The setting where this study took place was in the Doctor's Office, within the Athletic Training room at Adams State University (ASU), a small rural NCAA Division II institution in Alamosa, Colorado, located at 7544 ft. in altitude. The Athletic Training room is located in Plachy Hall (the athletic building). This study was completed after hours when the Athletic Training Room is closed to limit any distractions. Being in the Doctor's Office and taking place after hours, this allowed for optimal privacy of the participant. The participants were under the supervision of the researcher, a Certified Athletic Trainer, at all times.

Population

The population for this study consisted of 20 NCAA Division II collegiate men's and women's soccer, baseball, and women's lacrosse players who volunteered from Adams State University. Volunteers who had any low extremity injuries, visual problems, vestibular problems or a concussion within the last month, were excluded from the study. The participants were recruited by email, through Adams State University Athletics and with the approval of their coaches (Appendix F). Prior to beginning any testing or training, participants were given, explained, and signed an informed consent form (Appendix G), which was approved by the IRB at Adams State University.

Instrumentation

Prior to the start of the research, each subject completed basic demographics including height, weight, age, gender, and sport. This basic information was filled out by the Certified Athletic Trainer at the top of the SEBT scorecard (Appendix H). The height and weight were measured using a standard scale with height rod (Detecto Scale, Model 339), located in the Athletic Trainer Room in Plachy Hall. Leg length measurements was taken using a standard tape measure in centimeters. For the two tape conditions, two-inch Mueller kinesiology tape (KT) and two-inch wide Elastikon from Johnson and Johnson (placebo) were used due to accessibility and costs. Stainless steel super pro scissors were used to cut the tape. Prior to application of the tape, if any hair is present, it was shaved with a twin blade disposable razor, and then cleaned with Dynarex sterile alcohol prep pads. A blindfold was used so that the subjects did not know what condition was being applied. Both tapes were applied in a similar manner to maintain reliability and validity. Cramer tape remover was used on the skin after the tape was removed in order to remove any remaining tape residue, using a towel to help assist in removal. The same sterile alcohol prep pads were then used to clean the skin. Subjects were asked to bring or wear a pair of sweatpants.

Johnson and Johnson athletic tape was used to make the SEBT format as referenced by Hertel et al. (2006), along with a black sharpie marking out 1 cm increments along the tape using a tape measurer (Appendix D). A goniometer (Model G300) was used to create the 45-degree angles needed for the SEBT grid (Appendix D). A structured open-ended questionnaire was administered at the end of the SEBT (Appendix E). The questionnaire was taken by the subjects on a passcode locked laptop (2010 Apple Macbook 13.3 inch), saved on the computer, and a printed copy was filed away, locked in the Athletic Training room, where only the researcher, a Certified Athletic Trainer, had access.

Research Design

The study was a randomized, controlled crossover, single blind repeated measures design, and used to compare SEBT reach distance scores for the 3 ankle taping conditions: the kinesio tape, placebo tape, and the control (no tape). The participants were assigned a random number that identified them during the study. Depending on the assigned number this determined what condition they started with, whether starting with the application of kinesio tape, the placebo tape or the no tape condition. The athletes that started with the kinesio tape condition moved to the placebo tape, and then finished the study with no tape condition. The athletes that started with placebo tape condition moved to no tape, and then finished the study with the kinesio tape condition. Finally, the athletes that started with no tape moved to the kinesio tape, and finished the study with the placebo tape condition.

All participants were told before arrival for the test to bring or wear a pair of sweatpants. The sweats were used to block the subjects from seeing what condition they have on their ankle. Prior to testing, leg length measures of the non-dominant leg (reach leg) were done to normalize the test, and to allow for more accurate comparisons of performance among participants. Leg lengths were measured from the anterior superior iliac spine to the distal tip of the medial malleolus, and recorded on the data sheet (Appendix H). Demographics including height, weight, age, gender, and sport were also recorded on a data sheet by the researcher before testing (Appendix H). Prior to any testing, any hair present was removed with a razor and cleaned with sterile alcohol prep pads. All subjects had six practice trials in each of the eight directions of SEBT for the dominant leg to become familiar with the task, as recommended by Gribble et al. (2013), Hertel et al. (2006) and Olmsted et al. (2002). Each participant was asked to state their dominant leg; this was done by asking the participant which foot they would use to kick a ball (Wilkins, McLeod, Perrin, & Gansneder, 2004). The kicking foot was considered the dominant foot, which is the leg in which the tape was applied and the leg used during the SEBT to balance on (Wilkins et al., 2004). Prior to the practice trials, an explanation and demonstration of the SEBT was given to the subject. All subjects were required to complete all 8 reach directions before heading to the next practice trial. All trials were in sequential order in clockwise directions, starting with the anterior direction to keep consistency throughout the study, as recommended by Olmsted et al. (2002). Subjects were allowed 10 seconds in between each reach distance. After practice trials are complete with the dominant leg, subjects were allowed 5 minutes to rest before the testing started. The subjects that started with the no tape condition went straight into performing the SEBT following the protocol described by Gribble et al. (2012) and Hertel et al. (2006). Participants were required to maintain a stable single leg stance with the dominant leg in the middle of the grid, and were be asked to reach for maximal distance with the non-dominant leg in each of the eight directions (Appendix D). The subjects were asked to execute a touchdown, touching the floor without using the reach leg for support. The measurement was taken from the center of the grid to the reach distance in centimeters using a tape measure. Once the subject completed reach distances in all eight directions, they were allowed to complete the next two test trials. Subjects were allowed 10 seconds rest in between each reach, and 30 seconds between test trials. The three reaches in each direction of SEBT were recorded on a data sheet (Appendix H), and the average of the three calculated and used for analysis. Following standard protocol, trials were discarded and repeated if the subject (1) did not touch the line with the reach foot while maintaining weight on the stance leg, (2) lifted the stance foot from the center grid, (3) lost balance at any point in the trial, or (4) did not maintain and return the reach leg to starting position for one full second (Gribble et al., 2012). Participants were allotted 5 attempts to complete 3 reach distances in each of the eight reach directions; if not completed participants were replaced for this study. No participants were replaced during this study.

The subjects starting with one of the two taping conditions were asked to roll up their sweats and were blindfolded so they won't be able to see which tape was being applied. The investigator, a Certified Athletic Trainer, applied the ankle kinesio or placebo tape consistent with the kinesio taping methods (Kase, 2003) (Appendix I). According to standard protocol, the tape was applied to the ankle consistent with a completed functional correction to assist dorsiflexion and eversion; this correction limits plantar flexion and inversion, which is the most common mechanism of injury for a lateral ankle sprain (Appendix I) (Kase, 2003). The taping protocol started by placing the anchor with no tension on the medial aspect of the arch above the base of the 1st metatarsal (Appendix I) (Kase, 2003). Then the patient's ankle was put into dorsiflexion and eversion, bringing the I strip over the plantar surface with no tension (Appendix I) (Kase, 2003). Next, the tape was applied with 50% of tension to the I strip and the anchor was applied in the mid to proximal 1/3rd lateral aspect of the tibia with no tension (Appendix I) (Kase, 2003). Fifty percent tension was done by stretching the kinesio tape as far as it could go and then bringing it back to half the distance, according to standard protocol (Kase, 2003)

Once applied, the Certified Athletic Trainer vigorously rubbed the tape for 10 seconds to initiate adhesion prior to any further patient movement; this was done because KT tape adheres to the skin better with heat (Kase, 2003). The placebo tape was vigorously rubbed for 10 seconds to initiate adhesion as well so the participant couldn't tell the difference between the two tape conditions. To help maintain reliability and validity for tape placement, the researcher, who is a Certified Athletic Trainer, was the only one to apply tape to the participants, following the standard methods for application (Kase, 2003). Once done with the tape application, the Certified Athletic Trainer rolled down the sweats, took off the blindfold and the subjects performed the SEBT test trial.

After the three test trials, the subject was blindfolded and helped back to the table, where the tape was removed and any remaining residue removed with tape remover, and the skin cleaned with rubbing alcohol. The next tape condition was then applied and the SEBT protocol repeated exactly as described above. The time between the conditions was five minutes to allow time to remove the tape, reapply the new tape condition and allow the participant to rest. Participants were tested one at a time in the Doctor's Office, allowing room to ensure that they were not influenced by other subjects or the researchers and allow for optimal performance.

Once done with all three conditions for the SEBT test, each participant was required to fill out a structured, open-ended questionnaire about the athlete's perceived perceptions on the tape conditions (Appendix E). This was done on a laptop while alone in the testing room without the investigator, allowing for the participants to type their own answers and not be influenced by the researcher or other subjects. The open-ended questions allowed participants to identify their experiences associated with the conditions, while permitting the investigator to probe and clarify responses (Hunt & Short, 2006). The responses in the participant's own words become the raw data for the inductive content analysis (Hunt & Short, 2006). When the questionnaire was complete, it was saved onto the computer, and a printed copy was made as a back-up. After completing both the SEBT and the questionnaire, the subject was ask to not talk to any other subject about the study, so they don't skew the other tests scores or answers on the questionnaire for the other subjects. All data was kept in a locked filing cabinet and within a password protected computer in a locked office within the Athletic Training Room at Adams State, where only the researcher, a Certified Athletic Trainer, has a key.

Reliability

The SEBT test is a non-instrumented, simple, reliable, inexpensive dynamic balance test, and an alternative to more sophisticated instrumented methods (Gribble et al., 2012; Olmsted et al., 2002). The SEBT inter-rater reliability is excellent for the maximum excursion distances, with the ICC ranging from 0.86 and 0.92 (Bastien et al., 2014; Gribble, 2013; Hertel et al., 2006; Munro et al., 2010). Reliability for non-normalized measures, before leg length incorporated, are stronger, ranging from 0.89 to 0.94 (Gribble et al., 2013). The inter-rater reliability of the leg-length measurement is excellent (ICC (1,1) = 0.92, 95% confidence interval = 0.86, 0.96) (Gribble et al., 2013). Repeated testing using the SEBT is reliable after six trials are implemented to effectively account for the learning effect associated with the test (Hertel et al., 2006; Olmsted et al., 2002). During this study 6 practices trials in each of the eight directions of the SEBT were implemented. Once subject learning effects have been controlled for, intra-class correlation coefficients ranging from .85 to .96 for intra-tester reliability and from .81 to .93 for inter-tester reliability have been reported (Hertel et al., 2006). The intra-rater reliability of the SEBT is excellent (Gribble, 2013; Hertel et al., 2006; Bastien et al., 2014; Munro et al., 2010). The SEBT offers high reliability in evaluating dynamic balance and has the advantage of the capacity to measure the dynamic balance of both healthy and injured athletes (Hyong et al., 2014).

To ensure reliability for tape placement, the researcher was the only one to apply tape to the participants, following the standard methods for application (Kase, 2003). The protocol for the SEBT followed the standard procedures of Gribble et al. (2012) and Hertel et al. (2006), to ensure reliability. The structured open-ended questionnaire about the athlete's perceived perceptions on each of the three conditions consisted of the same questions, ensuring reliability.

Validity

The SEBT is a valid dynamic balance test to predict risk of lower extremity injury in healthy individuals, and also for identifying dynamic balance deficits in individuals with lower extremity conditions, through bilateral reach differences and reach distances smaller than leg length (Gribble et al., 2012). The SEBT demonstrates good measurement properties in regard to reliability, responsiveness, and content validity (Bastien et al., 2014). The SEBT provides a more accurate assessment of lower extremity function than static balance tests in healthy individuals (Gribble et al., 2012; Olmsted et al., 2002). Criterion validity of the SEBT has not previously been addressed in the literature by any known study (Sabin, 2011). No "gold standard" has been established or even proposed regarding a dynamic measure of balance that incorporates posture-kinetic movement (Sabin, 2011). The current study compared three conditions using the same tests (repeated measures crossover design) ensuring validity, since the subjects were all their own controls (Wellek & Blettner, 2012).

The researcher, a Certified Athletic Trainer, applied all the tape during the study, increasing intra-tester reliability and validity. As an Athletic Trainer, the researcher has a lot of experience taping athletes and knows the specific landmarks required for tape application, and followed the valid taping technique as recommended by Kase (2006). To ensure validity, the protocol for the SEBT followed the standard procedures Gribble et al. (2012) and Hertel et al. (2006). The responses to the questions on the structured open-ended questionnaire were answered by which tape condition is the most effective as perceived by the participants, measuring what it is intended to measure, ensuring validity, according to Gribble et al. (2012) and Hertel et al. (2006).

Treatment of Data/Statistical Analyses

The independent variables in this study are the tape conditions: kinesio tape, placebo tape, or control with no tape. The quantitative dependent variables are averaged normalized SEBT reach distances in all eight directions and the sum of all eight reach distances (Appendix H) for the kinesio tape, placebo tape, and the control (no tape) conditions. The qualitative dependent variables were the answers from the questionnaire (Appendix E).

The data collected from the leg length measurements and SEBT reach distances was organized in an Excel spreadsheet. The three trials for each of the eight directions of the SEBT were averaged, and the averages summed. Leg length dimension from the subjects were used to normalize the data (reach distance/leg length x 100). The SEBT reach distances in all eight directions for each condition (kinesio tape, placebo tape, and control) were analyzed using a multivariate analysis of variance (MANOVA), along with a one-way repeated measures analysis of variance (ANOVA). The sum of all 8 SEBT reach distances for each condition (kinesio tape, placebo tape, and control) were analyzed using a multivariate analysis of variance (MANOVA) along with a one-way repeated measures analysis of variance (ANOVA). If statistically significant results were found, Bonferroni post-hoc tests were run to determine which conditions were different. For all analyses, the statistical significance of $p < 0.05$ was used. All analyses for this study were done using the Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp., 2013), to determine if kinesio tape was effective in aiding dynamic balance using the SEBT.

The qualitative aspect of this study used an interpretative phenomenological analysis (IPA), and the qualitative analysis was based on the guidelines of Smith and Osborn (2007). Each athlete's responses to the questionnaire were independently studied and analyzed by the researcher, finding overall common themes from the study on the perceived perceptions the athletes had on the effectiveness, if any, for the different types of tape on their balance (Hunt & Short, 2006). The analysis was first completed by the researcher and then was compared with another unbiased researcher, to ensure validity. Any differences between them were discussed until a consensus was obtained (Hunt & Short, 2006). This qualitative information gained from the structured open-ended questionnaire helped determine if participants believed that kinesio tape was effective in aiding their balance or if it is merely a placebo effect.

Chapter 4: Results

Descriptive Data

Twenty participants (10 males and 10 females) volunteered to be in the study. All participants were healthy NCAA Division II athletes (5 baseball, 5 men's soccer, 5 women's soccer, and 5 women's lacrosse). The mean age of participants was 21.0 ± 1.26 years, height of 62.8 ± 4.5 inches, weight of 158.9 ± 29.03 lbs, and mean leg length of 92.35 ± 7.59 cm.

Quantitative Results

The MANOVA tests indicated no significant ($p > 0.05$) differences among the three tape conditions on the SEBT sum or any of the eight reach distances. For the specific statistical tests, see Appendix J. The nature of this effect is not clear from the multivariate test statistic, telling us nothing specific about which tape conditions differed from each other. The MANOVA test used for this study looked at the data as different individuals for each measure, instead of an individual going through the three tape conditions. Due to this effect, a one-way repeated measures ANOVA was used. An ANOVA with repeated measures is used to compare three or more group means where the participants are the same in each group (Field, 2013). This usually occurs in two situations: (1) when participants are measured multiple times to see changes to an intervention; or (2) when participants are subjected to more than one condition/trial and the response to each of these conditions wants to be compared (Field, 2013). For this study, participants were subjected to three conditions and the response (SEBT reach distances) to each condition was compared, following the second example of repeated measures ANOVA. Table 1 shows the reach distances as a mean and standard deviation for each direction and sum of the

SEBT. The p-value represents the comparisons of the tape conditions on the SEBT for each direction and sum.

Table 1. SEBT Directional Reach Distances

	KT (cm)	PT (cm)	NT (cm)	P-Value
Anterior	83.36 ± 7.67	81.63 ± 7.33	83.72 ± 7.9	0.121
Anterior Lateral*	74.33 ± 9.09	71.63 ± 8.78	73.94 ± 10.49	0.014*
Lateral**	77.80 ± 10.72	76.51 ± 12.56	79.86 ± 11.84	0.032**
Posterior Lateral	93.79 ± 11.17	92.69 ± 12.7	94.43 ± 9.98	0.475
Posterior	100.37 ± 10.69	100.33 ± 11.48	100.91 ± 10.21	0.853
Posterior Medial	101.61 ± 9.74	101.43 ± 9.6	102.4 ± 8.97	0.646
Medial	98.16 ± 7.7	97.72 ± 8.84	98.52 ± 7.9	0.685
Anterior Medial	90.09 ± 6.5	89.84 ± 7.82	90.07 ± 7.98	0.911
Sum	719.51 ± 56.84	711.77 ± 66.13	723.86 ± 59.78	0.182

Note. *p-value indicates that there was a significant difference between the KT and PT conditions for the SEBT anterior lateral reach distances.**p-value indicates that there was a significant difference between the PT and NT conditions for the SEBT lateral reach distances.

Mauchly's test indicated that the assumption of sphericity had not been violated $X^2(2) = 2.89$, p= 0.236. One-way repeated measures ANOVA found that there were significant differences in the SEBT anterior lateral reach distances $F(2,38)=4.804$, p= 0.014. Pairwise comparisons showed significant differences between KT (74.33 ± 9.09 cm) and PT (71.63 ± 8.78 cm) with a p-value= 0.014 in the Anterior Lateral direction of the SEBT (Appendix J). These results suggest that the KT condition showed a significantly larger reach distance compared to the PT condition.

Mauchly's test indicated that the assumption of sphericity has not been violated $X^2(2) = 2.78$, p= .249. One-way repeated measures ANOVA found that there were significant differences in the SEBT lateral reach distances $F(2,38)= 3.78$, p= 0.032. Pairwise comparisons showed significant differences between PT (76.51 ± 12.56 cm) and NT (79.86 ± 11.84 cm) with a p-value= 0.032 in the Lateral direction of the SEBT (Appendix J). These results suggest that the NT condition showed a significantly larger reach distance compared to the PT condition. No other significant group differences (p>0.05) were found for any other reach distance as shown in Table 1.

Mauchly's test indicated that the assumption of sphericity had been violated $X^2(2)$ =7.189, p= .027, therefore degrees of freedom were corrected using the Greenhouse-Geisser test estimate of sphericity. One-way repeated measures ANOVA did not find significant differences between tape conditions for the SEBT sum, F(1.313,24.949)= 1.881, p= .182. These results suggest that the overall SEBT scores were not significantly different between the three tape conditions.

Qualitative Results

Table 2 indicates whether the participants would use Kinesio tape (KT) or Placebo (PT) conditions in the future to aid with balance. These answers were based off the questionnaire given to each participant after the SEBT balance test was complete under each of the three conditions. Results suggest that the majority of participants (80%) would use KT again in the future for balance, whereas 20% of participants reported that they wouldn't use KT in the future. When looking at PT, the results show that the majority of participants (65%) wouldn't use PT in the future for balance, while 35% of participants suggested that they would use PT in the future.

Table 2. Tape Conditions Future Use

Future	KT	PT	Future	KT	PT
Yes	16	7	Yes	80%	35%
No	4	13	No	20%	65%

Table 3 indicates a ranking of which tape condition the participants believed was the most effective for aiding balance. These answers were based off the questionnaire given to each participant after the SEBT balance test was complete under each of the three conditions. Results suggest that the majority of participants ranked no tape (NT) as the most effective in aiding balance (45%), followed by KT (35%), and PT (20%). These results also indicate that participants ranked KT as the second most effective in aiding balance (50%), followed closely by NT with 40%, and PT at 10%. Participants ranked PT as the worst of the three conditions for aiding balance with 70% of the third place votes, followed by KT and NT both equally getting 15% of the votes.

Table 3. Tape Conditions Ranking

Rank	KT	PT	NT
1	7	4	9
2	10	2	8
3	3	14	3

Rank	KT	PT	NT
1	35%	20%	45%
2	50%	10%	40%
3	15%	70%	15%

Chapter 5: Discussion

Discussion of Results

The purpose of this study was to determine if an application of kinesio tape to the ankle was an effective measure in aiding balance using a dynamic measure of balance, the star excursion balance test (SEBT). A structured open-ended questionnaire was administered to determine if participants believe the kinesio tape actually worked or if it is merely a placebo effect. The original hypothesis was that there would not be any statistically significant ($p > 0.05$) differences between tape conditions during the SEBT. Overall, the results of the study showed there was no statistically significant ($p > 0.05$) reach distance differences between all three tape conditions, showing that no matter what tape condition was applied to the participants, their SEBT scores were similar.

Although the overall SEBT showed no significance reach differences between any of the three conditions, two specific directions (Anterior Lateral and Lateral) showed significant differences in reach. These findings went against the original hypothesis that kinesio tape would not be effective (i.e., not statistically significant, $p > 0.05$) in aiding balance in any of the eight directions of the SEBT due to its placebo effect. The Anterior Lateral direction showed significant difference in reach distance for kinesio tape and placebo groups. Pairwise comparisons showed significant differences between KT (74.33 ± 9.09 cm) and PT (71.63 ± 8.78 cm) with a p-value= 0.014 in the Anterior Lateral direction of the SEBT (Appendix J). The kinesio tape group had a significantly further reach distance than the placebo, although the kinesio tape didn't differ significantly from no tape group. For the Lateral direction, pairwise comparisons showed significant differences between PT (76.51 ± 12.56 cm) and NT ($79.86 \pm$

11.84 cm) with a p-value= 0.032 in the Lateral direction of the SEBT (Appendix J). The no tape condition had significantly further reach distance than the placebo, although the no tape didn't differ significantly from the kinesio condition. Although KT had significant differences compared to PT in the Anterior Lateral direction and NT had significant differences compared to PT in the Lateral direction, it can't be claimed from these findings that KT or NT are better in aiding balance than the other, since it was only significant in one of eight directions of the SEBT.

It was also hypothesized that the athletes would perceive the kinesio tape to be the most effective, with the no tape group being the least effective. The participants ranked which tape conditions they believed were the most to least effective for aiding balance. Refer back to Table 3 for participants' rankings from the questionnaire. Contradicting the hypothesis, results suggest that the majority of participants ranked no tape (NT) as the most effective in aiding balance (45%), followed by KT (35%), and PT (20%). These results also indicate that participants ranked KT as the second most effective in aiding balance (50%), followed closely by NT with 40%, and PT at 10%. Participants ranked PT as the worst of the three conditions for aiding balance with 70% of the third place votes, followed by KT and NT both equally getting 15% of the votes. Overall, NT ranked 1st, KT 2nd, and PT 3rd for which tape condition participants believed was the most effective in aiding balance during the SEBT.

Research Question 1: Will the kinesio tape be effective in aiding balance compared to placebo tape and no tape conditions?

This is a discussion of kinesio tape being an effective aid in balance compared to placebo tape and no tape conditions. Kinesio tape (KT) is proposed to cause an increase in proprioception through increased stimulation to cutaneous mechanoreceptors, hence aiding in balance (Halseth et al., 2004). Halseth et al. (2004) examined the effects of applying kinesio tape to the anterior and lateral ankle on proprioception compared to an untaped ankle, and their results led to the conclusion that kinesio tape does not appear to enhance proprioception in healthy participants. When comparing the effects of kinesio tape on ankle proprioception between healthy participants and participants with chronic ankle instability (CAI), Simon et al. (2014) found that KT could improve proprioception in participants with CAI to the level that would be similar to those who have never sustained an ankle injury. However, kinesio tape didn't improve their proprioception better than the individuals who never sustained an ankle injury. With contradicting research on KT and improving proprioception, this current study showed that kinesio tape was not effective in aiding balance during the SEBT when compared to placebo tape and no tape conditions. Results showed no significant reach differences between all three tape conditions ($p>0.05$), meaning that no matter what tape condition was applied to the participants, SEBT scores were similar, suggesting no balance or proprioception improvements from KT. Bicici et al. (2012) also found that KT had no significant effect on performance during the SEBT; nor did it help performing a hopping test, single limb hurdle, and dynamic balance tests.

Along with Bicici et al. (2012), Fayson et al. (2013) also found that there was no effect of KT tape on time to stabilization, showing KT has no effect on proprioception in the ankle or dynamic balance. When using a static balance test, Achatz (2015) found that kinesio tape also isn't an effective measure in aiding static single leg balance, due to increased errors during the Balance Error Score System (BESS) test for the kinesio tape and placebo tape conditions, compared to a lower number of errors for the no tape condition. In fact, balance appeared to worsen with the tape compared to the no tape condition (Achatz, 2015). In this current study, kinesio neither increased nor decreased balance during the SEBT when compared to placebo tape and no tape conditions.

Research Question 2: Will the kinesio tape be effective in aiding balance in all eight directions of the SEBT compared to placebo tape and no tape conditions?

The SEBT is a reliable and valid dynamic balance test (Gribble et al., 2012). Since kinesio tape is proposed to increase proprioception and thus lead to increased balance (Halseth et al., 2004), this would mean that kinesio tape should be more effective in aiding balance compared to placebo and no tape conditions. Although the SEBT results of this current study showed no overall reach differences between all three of the conditions in any of the directions, unexpectedly two directions (Anterior Lateral and Lateral) did show significant differences in reach distances ($p < 0.05$). When looking at the Anterior-Lateral direction, the kinesio tape and placebo conditions showed significant differences between each other in reach distances. Pairwise comparisons showed these significant differences ($p<0.05$) between KT (74.33 ± 9.09 cm) and PT (71.63 ± 8.78 cm) in the Anterior Lateral direction of the SEBT (Appendix J). These results suggest that the KT condition allowed a significantly larger reach distance compared to the PT condition, although the KT condition didn't have any significant differences with the NT condition. This current study suggests that KT would be a better option for balance in the Anterior Lateral direction than PT, but has no difference in balance compared to NT. Similarly, Thelen and colleagues (2008) found that KT applied to patients with rotator cuff tendonitis/impingement may have immediate improvement in pain-free shoulder abduction compared to NT, but the KT appears to not be more effective than the PT.

For the Lateral reach direction, the pairwise comparisons showed significant differences in reach distances ($p<0.05$) for placebo tape and no tape conditions, with values for PT (76.51 ± 12.56 cm) and NT (79.86 ± 11.84 cm) (Appendix J). These results imply that the NT condition showed a significantly larger reach distance compared to the PT condition, even though the KT condition didn't have any significant differences with the NT condition. This current study proposes that NT would be a superior option for balance in the Lateral direction compared to PT, but is not different in balance compared to KT. Yoshida and Kahanov (2007) found that KT applied to the back may improve active range of motion in lower trunk flexion, but not for lateral flexion and extension. Showing similar results to the current study, Yoshida and Kahanov's (2007) study didn't show an overall trunk range of motion increase compared to NT but may cause a slight increase in one direction (flexion). Briem and colleagues (2011) also found that non-elastic tape (PT) may enhance muscle activity of the fibularis longus, potentially enhancing dynamic support of the ankle. The efficacy of KT in preventing ankle sprains via the same mechanism as the PT is unlikely, as it had no effect on muscle activity of the fibular longus, showing similar results to NT (Briem et al., 2011). This relates to the current study by PT having a potential dynamic support of the ankle leading to increased balance. The current study showed improved balance with NT in the Lateral direction and KT in the Anterior Lateral directions but had no effect on balance for the other six directions. This improvement could potentially be due to the tape being applied to the ankle in the lateral direction (ankle inversion) allowing for more stability in the lateral directions.

Research Question 3: What are the perceived perceptions the athletes have on the effectiveness for the kinesio tape, placebo tape, and no tape on their balance?

When referring back to Table 3 that shows the ranking of which tape conditions the participants believed was the most effect for aiding balance, results suggest that the majority of participants ranked no tape (NT) as the most effective in aiding balance (45%), followed by KT (35%), and PT (20%). These results also indicate that participants ranked KT as the second most effective in aiding balance (50%), followed close by NT with 40%, and PT at 10%. Participants ranked PT as the worst of the three conditions for aiding balance with 70% of the third place votes, followed by KT and NT both equally getting 15% of the votes. Overall this means that NT ranked 1st, KT 2nd, and PT 3rd for which tape condition participants believed was the most effective in aiding balance during the SEBT. Similarly, Sawkins et al. (2007) examined the perceptions of athletes using three different tape conditions (athletic tape, no tape and proprioceptive placebo tape) during a hopping test and modified star excursion balance test (SEBT). The proprioceptive (placebo) tape consisted of a single strip of inelastic tape approximately 10 cm long on the lateral aspect of the lower leg above the lateral malleolus (Sawkins et al., 2006). Results showed participants felt that the athletic tape condition was the most effective condition, with more participants reporting improvements in perception of stability, confidence and reassurance compared to no tape and the proprioceptive (placebo) tape (Sawkins et al., 2006).

The perceived perceptions the athletes had on the effectiveness for kinesio tape, placebo tape, and no tape on their balance was done by the questionnaire and then put into Table 2. This table shows the results of the participants when asked if they would use kinesio tape or placebo tape in the future. Results suggest that the majority of participants (80%) would use KT again in the future for balance, whereas 20% of participants reported that they wouldn't use KT in the future. When looking at PT, the results show that the majority of participants (65%) wouldn't use PT in the future for balance, while 35% of participants suggested that they would use PT in the future. Overall this means that more people reported that they would use KT (80%) in future than PT (35%).

Table 4 shows all the common themes found of the participants' experiences using each taping condition, along with the reasons for using the tape conditions in the future and why they ranked the tape conditions as they did. The common experiences the KT conditions had on the participants were less restrictive, better balance, comfortable, flexible, more control, stable, felt like nothing was there, and lighter. The common experiences the PT conditions had on the participants were restrictive, too tight, heavy, thick, more supportive, sturdy and more pressure. The common experiences the NT conditions had on the participants were more movement, natural, best balance, not restrictive, no/less support, and could reach further distances.

When looking at Table 4, the reasons why participants said that they would use KT in the future are because it didn't irritate, most effective, comfortable, no pain, helped with fatigue, flexible and more balance. The reasons participants wouldn't use KT in the future are because participants felt it was flimsy and not supportive. When looking at the reasons why participants said that they would use PT in the future it was because it felt thicker, helped ROM, more sturdy, secure and stable. The reasons participants wouldn't use PT in the future are because participants felt it was too restrictive, no control, more pressure and didn't help or make a difference. For this study participants weren't asked if they would use NT in the future because all of them already use it daily and will in the future.

Table 4. Experience With Tape Conditions

	KT	PT	NT
Experience	Somewhat/less restrictive	Restrictive	More movement
	Better/more balance	Stuck really well	More natural
	Not benefital	Very tight	Best balance
	Didn't stick as well as PT	Too hot	Focus on balance better
	Not hot	Not helpful	Wasn't restrictive
	Comfortable	Felt unbalanced	Felt Free
	Flexible	Helped a little in balance	No/less support
	Not heavy	Feel it more	Stretch out further
	More stable	Heavy/thick	
	More control	Help reach further	
	Move easier	More pressure	
	Similar to no tape	More sturdy	
	Nearly forgot it was on	More supportive	
	Felt like nothing there	Tougher material	
	Lighter		
Future	Flexible	Felt thicker/heavier	
	More balance	Too restictive	
	Most effective	No control	
	Didn't irritate	Helped increase ROM	
	Comfortable	Didn't make a difference	
	Stable	Didn't help	
	Felt in control	More pressure	
	No pain	Sturdy/secure/stable	
	Helped with fatigue		
	Flimsy		
	Non-supportive		
Ranks	Wasn't/less Restrictive	Constricting	More natural
	More in control	Harder to balance	Most comfortable
	Stable	More supportive	No extra support
	More ROM		Wobbly
	Helped when Fatigued/Tired		Less confident
	Provided confidence		Move movement/ROM
	Most effective		
	More support		
	More balance		

For those participants that ranked KT the highest in aiding balance, the reasons are KT is supportive, flexible, allowed for more ROM, most effective in aiding their balance, in control and allowed them the most balance. The reasons for some participants ranking NT the highest as the most effective in aiding balance were it is more natural, most comfortable, more movement and range of motion allowing for further reach distances. The reasons why some participants in this current study ranked PT the highest as the most effective condition for aiding balance was due to it being more supportive, allowing for better balance and being able to reach further distances during the SEBT. However, the PT was ranked as the least effective in aiding balance by most participants (70%), stating that it was too constricting and harder to balance with due to its limited ROM during the SEBT.

Like the current study, Dulahunt et al. (2010) investigated the effects of three taping conditions (no tape, subtalar sling, fibular repositioning tape) on actual and perceived dynamic postural stability in people with chronic ankle instability using the SEBT. Their study indicated that there was no significant difference in actual SEBT scores in any of the conditions; however participants had a significant increase in perceived stability, confidence, and reassurance for both taping conditions compared to the no tape condition (Delahunt et al., 2010). Gear and colleagues (2011) also examined the effects of ankle taping and bracing on dynamic balance and perception of stability. No significant differences between conditions (barefoot, taped, braced) were found for overall stability, although significant differences were found for the participants' perception of support (Gear et al., 2011). Participants indicated that ankle tape and bracing provided a false sense of increased stabilization of the ankle, feeling as though they had increased stability although results showed otherwise (Gear et al., 2011). These findings are also in agreement with other studies (Hunt & Short, 2006: Sawkins et al., 2007) that ankle taping and bracing does not affect stability in quantitative tests, but there may be a perception from the participants that tape provides increased stabilization of the ankle.

Placebo Effect

Although kinesio tape didn't aid in balance during the SEBT in the current study, many participants mentioned during the questionnaire that they felt kinesio tape was the best condition for aiding balance (35%), still lower than NT (45%), with 80% reporting that they would use kinesio tape in the future for aiding balance. These findings were interesting knowing the fact that kinesio tape didn't help or decrease balance during the SEBT. This is where the researcher believes there is a placebo effect for using kinesio tape. The placebo effect is a favorable outcome arising purely from the perception or belief that one has received a beneficial treatment (Duncan et al., 2009). One participant during the current study reported during his or her questionnaire that he/she thought the KT gave them a sense of confidence, stability, allowing them to balance better and reach further distances during the SEBT. A sense of confidence during certain movements is an important aspect during any sport (Sawkins et al., 2006).

Another participant stated "I felt that the first tape (KT) helped my balance. I felt stable going in every direction and it seemed that I had more control and balance". This is another example of a participant believing that kinesio tape was the best condition for aiding balance during the SEBT, although there was no significant differences between conditions for the overall SEBT. These results suggests that although kinesio tape had no influence on SEBT balance based on quantitative scores, it did affect the way individuals felt or perceived the kinesio tape during the SEBT. This is in agreement with other studies that reported similar conclusions of no significant differences in functional/balance tests, however participants had an increase in perceived stability, and confidence with both taping conditions compared to no tape condition (Delhunt et al., 2010; Gear et al., 2011; Hunt & Short, 2006). Hunt and Short (2006) explored college athletes' perceptions of adhesive ankle taping through a series of semi-structured interviews, which included a series of open-ended questions. Results showed that taping has an physchological impact on these athletes, in that their perceptions of the tape indicated feelings of increased confidence, increased strength, and decreased anxiety for injury or re-injury (Hunt & Short, 2006).

Similarly, Sawkins et al. (2007) found no significant effects of placebo taping in their study. However, in the study conducted by Sawkins et al. (2007), participants reported improved perceptions of stability, confidence and reassurance with the placebo tape in place while performing functional tests. Duncan and colleagues (2009) also found similar results when they investigated the placebo effect of caffeine on short-term resistance exercise to failure. The researchers found that there was a significant difference in the total repetitions completed when they believed they had consumed caffeine compared with the control condition when they thought they had consumed a placebo (Duncan et al., 2009).

Gate Control Theory

The proposed mechanism for the relief of pain from KT is through the stimulation of sensory pathways in the nervous system, thus increasing afferent feedback (Williams et al., 2012). This is thought to diminish the input from nerves conducting nociception (pain) signals due to the gate control theory (Williams et al., 2012). These afferent (sensory) nerves inhibit the effects of the pain nerves, closing the "gates" to painful input, which prevents pain sensation from traveling to the central nervous system (Prentice, 2009). Therefore, stimulation of the sensory nerves is able to suppress pain (Prentice, 2009). This concept of sensory stimulation for pain relief, as proposed by the gate control theory, has empirical support (Prentice, 2009).

One participant after completing the SEBT under all three conditions, reported in his or her questionnaire "I was getting a sharp little pain when I didn't have any tape, but didn't have any pain with the first tape (KT)". This led to this certain participant ranking KT as the best and most effective condition for aiding in his or her balance. A decreased pain during balance would suggest that the participant could have a further reach distance during the SEBT. This is in agreement with other studies that reported similar conclusions that KT is an effective tool in reducing pain through the gate control theory (Campolo et al., 2013; Gonzales-Enciso, 2009; Merino-Marban et al., 2014). Campolo et al. (2013) compared two taping techniques (kinesio and McConnell), and investigated their effect on anterior knee pain during functional activities. Results showed that no significant differences in the three conditions in the functional performance, but the kinesio tape and McConnnell tapes provided significant pain reduction compared to the no tape condition (Campolo et al., 2013). Merino-Marban and colleagues (2014) found that the application of kinesio tape to the calf showed no affect on calf extensibility either immediately before or after a competition among duathletes. However, the results suggested that KT application may reduce calf pain produced by a duathlon competition (Merino-Marban et al., 2014). This relates to the current study in the fact that kinesio tape had no difference in performance but it did affect how the participants felt mentality about the kinesio tape. Whether the KT helped with decreased pain like in the Merino-Marban et al. (2014) study, or having increased perception of balance like the current study, the participants felt that the KT gave them increased perceptions of effectiveness.

Support

Another discussion point is the support or lack of support from the tape application, allowing for increase or decreases in perceived balance by the participants during the SEBT. Through the questionnaire, participants either reported that the tape conditions were too restrictive, allowing for less range of motion and decreased reach distances, or they thought the tape conditions gave them more stability and confidence allowing for further reach distances. Referring back to Table 3 one participant reported, "I felt like tape #2 (KT) helped me a little more as I got tired and fatigued". This may suggest that KT could be used as an athlete becomes fatigued to increase stability allowing them to continue with activity without balance problems. The reason for this may be the proprioceptive feedback; as they become fatigued or tired the KT could increase the person's joint awareness leading to better balance (Miralles et al., 2014).

When looking at the differences between KT and PT, although participants never saw what tape conditions they had on during the study, the consensus for the majority of the participants was the same, that KT was less restrictive and more effective than PT. This is backed up by the fact that 70% of the participants ranked PT as the less effective in aiding their balance during the SEBT. For example, one participant stated "Tape #1 (KT) moved a lot more with foot/ankle, it wasn't as restricting as tape #2 (PT)". This supports Dr. Kase who claims that KT supports muscle and joints without the restricting components of non-elastic tape, causing a more comfortable feel, allowing athletes to be more functional and stay in the game (Kase, 2003). After looking at the participants' reactions to the no tape condition, participants either reported that the no tape was less restrictive, allowing them to reach further distances or that no tape made them feel less stable or wobbly leading to decreased reach distances. For example, one participant stated "No tape seemed more natural and comfortable, allowing for less restriction and more range of motion, which allowed me to reach out further".

Practical Applications

This study found that kinesio tape was not effective in terms of quantitative measures of balance during the SEBT when compared to placebo tape and no tape conditions (statistical significance $p>0.05$). There are a few things however that can be taken from this study and brought into the athletic field. A Certified Athletic Trainer or any health care professional may use kinesio tape for reducing pain in an athlete. As mentioned before, the gate control theory supports a potential use for kinesio tape on an injured or hurt area on an athlete to reduce pain (Campolo et al., 2013; Gonzales-Enciso, 2009; Merino-Marban et al., 2014). Decreasing one's pain allows an athlete to perform better and increases their confidence (Campolo et al., 2013; Gonzales-Enciso, 2009; Merino-Marban et al., 2014). Confidence is an important feeling in athletics that allows an athlete to enhance performance (Sawkins et al., 2006). Although kinesio tape had no quantitative influence on SEBT balance, participants had an increase in perceived stability, confidence, and reach distances. Whether pain relief or increased confidence, kinesio tape could be used in the future as a placebo effect when alternative measures or treatments don't work.

Recommendations

This study opens the doors for many possible future studies and also brings to light some changes that need to be addressed. Knowing that kinesio tape isn't an effective tool in aiding in balance during the SEBT in healthy individuals, a future study might look at the effectiveness of kinesio tape on an injured population. A study in an injured population could look at the potential of kinesio tape to increase balance, and for potential proprioception effect or the placebo effect to decrease pain which might allow for increased balance. Since no significance was found during the SEBT, future studies could also look at the effects of kinesio tape while using different static or dynamic balance tests, for example the Balance Error Scoring System (BESS), Romberg test, Four Square Step Test (FSST), Berg Balance Scale (BBS), Computerized Dynamic Posturography, and many more.

The placebo tape for this study was elastikon; for future studies a different tape that is more similar to kinesio tape could be used, including elastic tape such as Jaylastic, Sherlight, and Tearlight. This study used Mueller kinesio tape, so further research could also look at the effects of other types of kinesio tape such as Kinesio® Tex Classic, Kinesio® Tex Gold, KT TAPE™, KT TAPE™ Pro and their effects on balance. For this current study comparisons were only made between tape conditions; future research could look at comparisons between dominant and non-dominant legs while using kinesio tape and other tapes. A study could look at one gender possibly being more affected by the kinesio tape. Age differences could be looked at when using kinesio tape, since as you become older your nervous system weakens and due to kinesio tape's potential to increase proprioception, potentially helping the elderly with balance. Future studies could also look into sport differences, seeing if kinesio tape potentially helps balance in one sport more compared to another. Since only men's and women's soccer, baseball, and women's lacrosse athletes were used for this study, other potential studies could be done looking at any other sports that weren't used for this study. A study could look at the differences in balance between sports, due to some sports potentially requiring better balance than others such as gymnastic versus football. Future research could also potentially look at differences between genders in sports such as men's and women's soccer or basketball.

Kinesio tape may also be used to help circulation, from its abilities to lift the skin from the underlying fascia, increasing blood and lympathic flow, which might result in increase oxygen allotment to the muscle, decreasing inflammation, and improved anaerobic muscle function (Stedge et al. 2012). Although this is something that wasn't examined during this current study, further research could be done looking at the differences between kinesio tape and other tape products on increased circulation.

Conclusion

When examining the results of this current study, it can be concluded that kinesio tape is not effective in aiding balance during the SEBT results when compared to placebo tape and no tape conditions. Results showed no significant reach differences between all three tape conditions ($p > 0.05$). In spite of the fact that the SEBT results of this present study demonstrated no overall reach differences between conditions, two directions (Anterior Lateral and Lateral) showed significant differences ($p<0.05$). Pairwise comparisons demonstrated significant differences between KT (74.33 ± 9.09 cm) and PT (71.63 ± 8.78 cm) in the Anterior-Lateral direction of the SEBT (Appendix J). This current study proposes that KT could potentially be a superior alternative for balance in the Anterior Lateral direction than PT, yet has no difference in balance compared with NT. Pairwise comparisons showed significant differences ($p<0.05$) between PT (76.51 ± 12.56 cm) and NT (79.86 ± 11.84 cm) in the Lateral direction of the SEBT (Appendix J). The current study suggests that NT may be a better option for balance in the

Lateral direction than PT, yet has no difference in balance compared to KT. The overall finding of this current study is that kinesio tape is not effective in aiding balance during the SEBT when compared to PT and NT, even though participants reported improved perceptions of stability, confidence and reassurance with the kinesio tape in place while performing the SEBT.

Chapter 6: Summary and Conclusions

Summary

The purpose of this study was to determine if an application of kinesio tape to the ankle is an effective measure in aiding balance using a dynamic measure of balance, the star excursion balance test (SEBT). The population for this study consisted of 20 NCAA Division II collegiate men's and women's soccer, baseball, and women's lacrosse players who volunteered from Adams State University. Specifically, this study aimed to looking at kinesio tape's effect on overall SEBT scores, along with individually looking at each of the eight directions of the SEBT compared to placebo tape and no tape conditions. A structured open-ended questionnaire was administered to determine if participants believe the kinesio tape actually worked or if it is merely a placebo effect.

To examine these questions, all participants completed the SEBT under three tape conditions: the kinesio tape, placebo tape, and the control (no tape). The participants were assigned a random number that identified them during the study and depending on the assigned number it determined what condition they started with, whether it is starting with the application of kinesio tape, the placebo tape or the no tape condition. All subjects had 6 practice trials in each of the 8 directions of SEBT for the dominant leg to become familiar with the task, as recommended by Gribble et al. (2013), Hertel et al. (2006) and Olmsted et al. (2002). The dominant foot was the leg in which the tape was applied and the leg used during the SEBT to balance on. The three reaches in each direction of SEBT were recorded on a data sheet (Appendix H), and the average of the three calculated and used for analysis. Once done with all three conditions for the SEBT test, each participant was required to fill out a structured, open-ended questionnaire about the athlete's perceived perceptions on the tape conditions.

The SEBT was chosen for being a valid and reliable dynamic balance test to predict risk of lower extremity injury in healthy individuals, and also for identifying dynamic balance deficits in individuals with lower extremity conditions, through bilateral reach differences and reach distances smaller than leg length (Bastien et al., 2014; Gribble et al., 2012; Gribble, 2013; Olmsted et al., 2002). The researcher hypothesized that the kinesio tape would not be effective in aiding balance due to its placebo effect. It was also hypothesized that the kinesio tape would not be effective in aiding balance in any of the eight directions of the SEBT due to its placebo effect. Last, it was hypothesized that the athletes would perceive the kinesio tape to be the most effective, with the no tape group being the least effective.

The results from this study support the main hypothesis as the data revealed no significant ($p > 0.05$) differences among the three tape conditions during the SEBT. Contradicting the second hypothesis, two directions (Anterior Lateral and Lateral) showed significant ($p < 0.05$) differences in reach distances. The Anterior Lateral direction showed significant ($p < 0.05$) differences in reach distance for kinesio tape and placebo conditions. The kinesio tape condition had significantly further reach distance than the placebo, although the kinesio tape didn't have any significant differences compared to the no tape condition. The Lateral direction showed significant ($p < 0.05$) differences in reach distance for no tape and placebo conditions. The no tape condition had significantly further reach distances than the placebo, although no tape didn't have any significant differences with the kinesio tape condition.

The results of the study also contradicted the last hypothesis that the athletes would perceive the kinesio tape to be the most effective, with the no tape group being the least effective. Through the questionnaire, results showed that the majority of participants ranked no tape (NT) as the most effective in aiding balance (45%), followed by KT (35%), and PT (20%), although 80% of participants suggested that they would use kinesio tape in the future. Overall, this would suggest that although kinesio tape had no effect on aiding balance during the SEBT, approximately one-third of participants perceived kinesio tape as the most effective in aiding balance during the SEBT due to improved perceptions of stability, confidence and reassurance with the kinesio tape in place, in the end giving the participants a placebo effect.

Conclusion

Kinesio tape is not effective in aiding balance during the SEBT when compared to placebo tape and no tape. However, kinesio tape apparently affected how the participants perceived its effectiveness during the SEBT. Kinesio tape could potentially be used as a placebo to improve balance or to reduce pain. The effects of kinesio tape on balance needs to be studied further.

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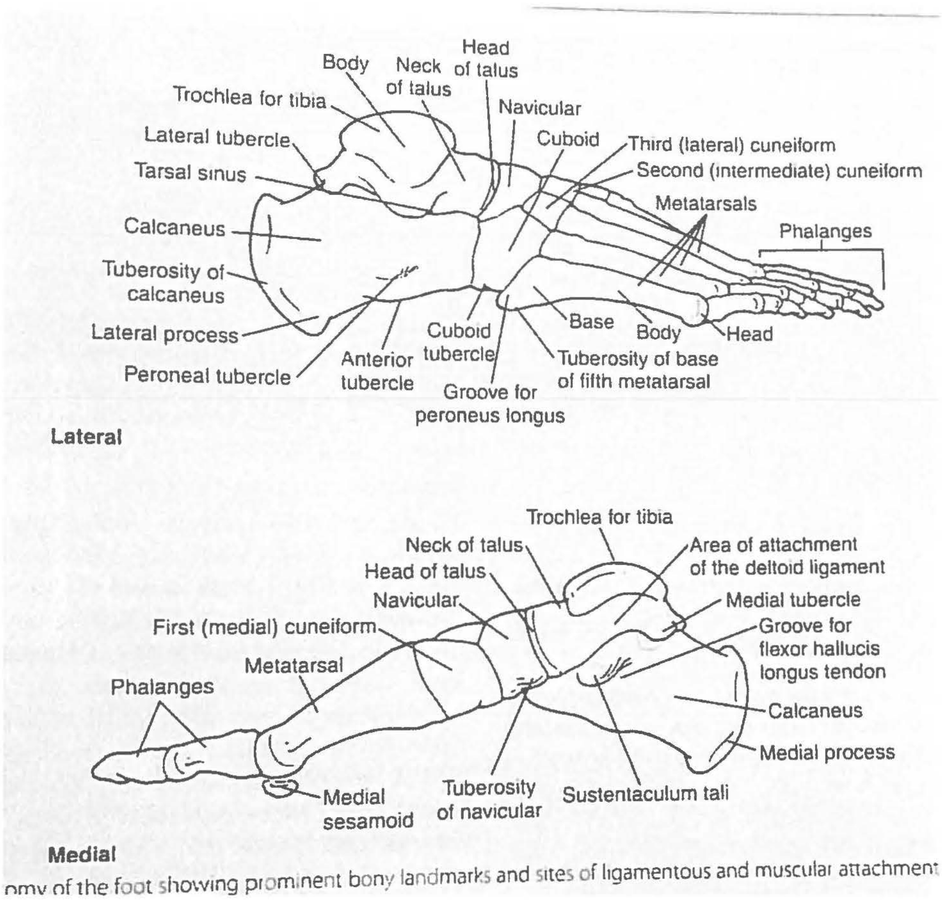
Appendices

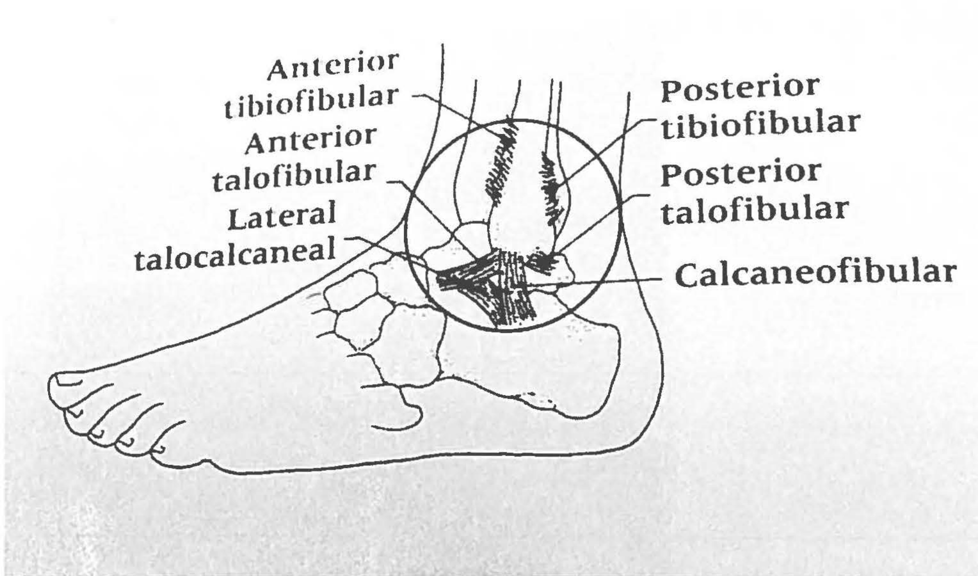
Appendix A: Bones of the Ankle

Ankle Bones (Lateral view)

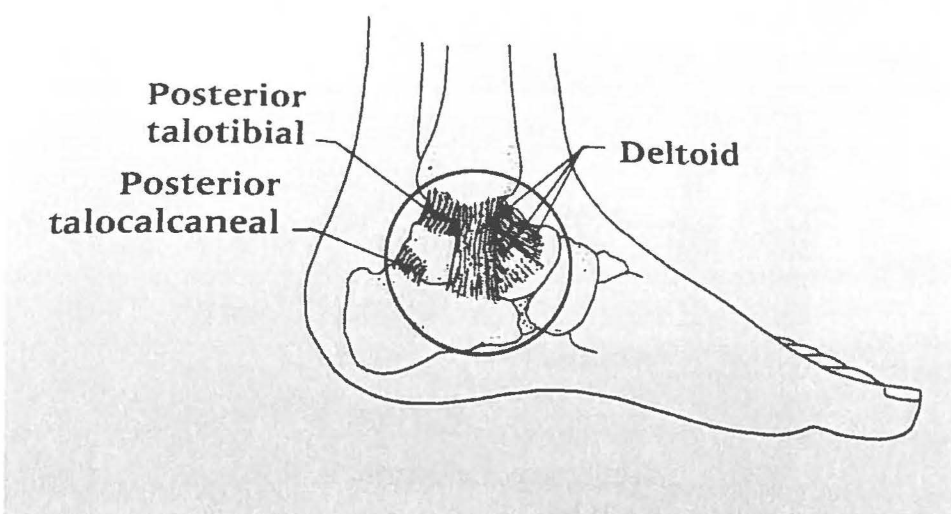


Ankle Bones (Medial view) (Arnheim & Prentice, 2000)

Appendix B: Ligaments of the Ankle



Ankle ligaments (Lateral view) (Arnheim & Prentice, 2000)



Ankle Ligaments (Medial view) (Arnheim & Prentice, 2000)

Appendix C: Muscles of the Leg

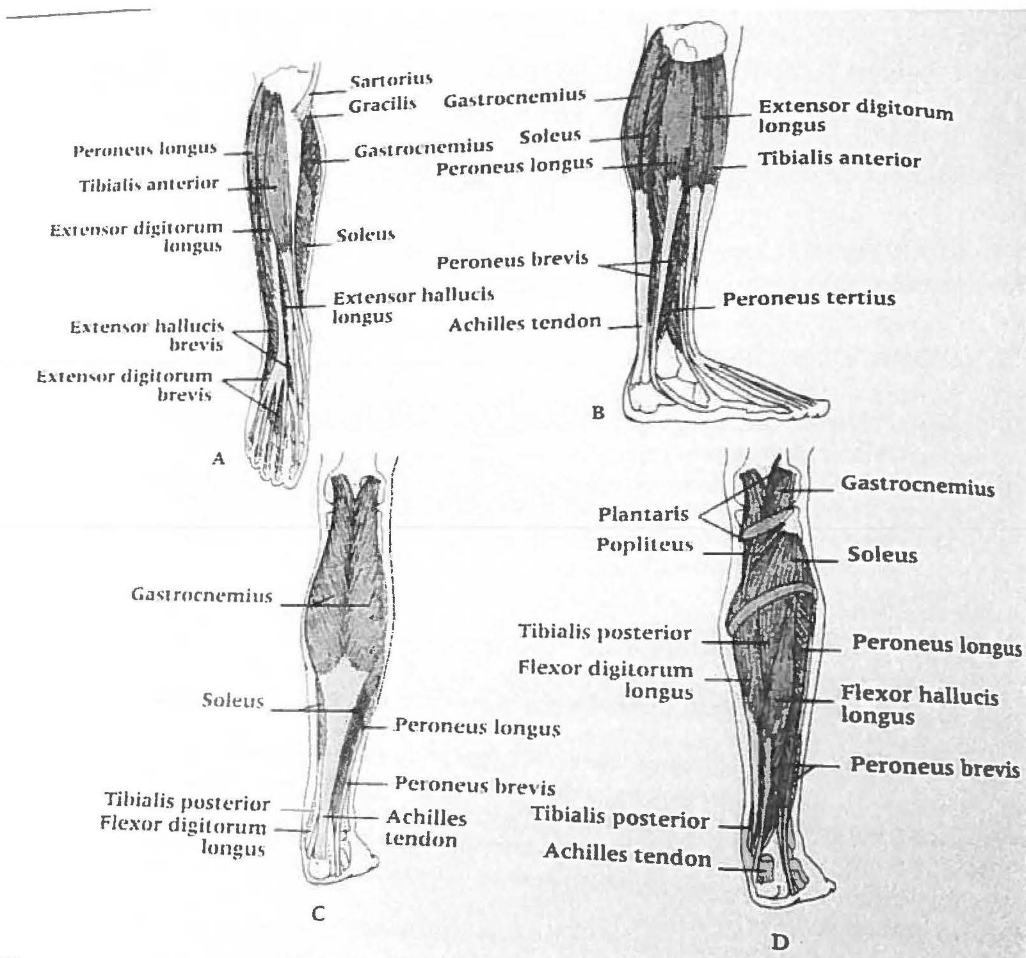
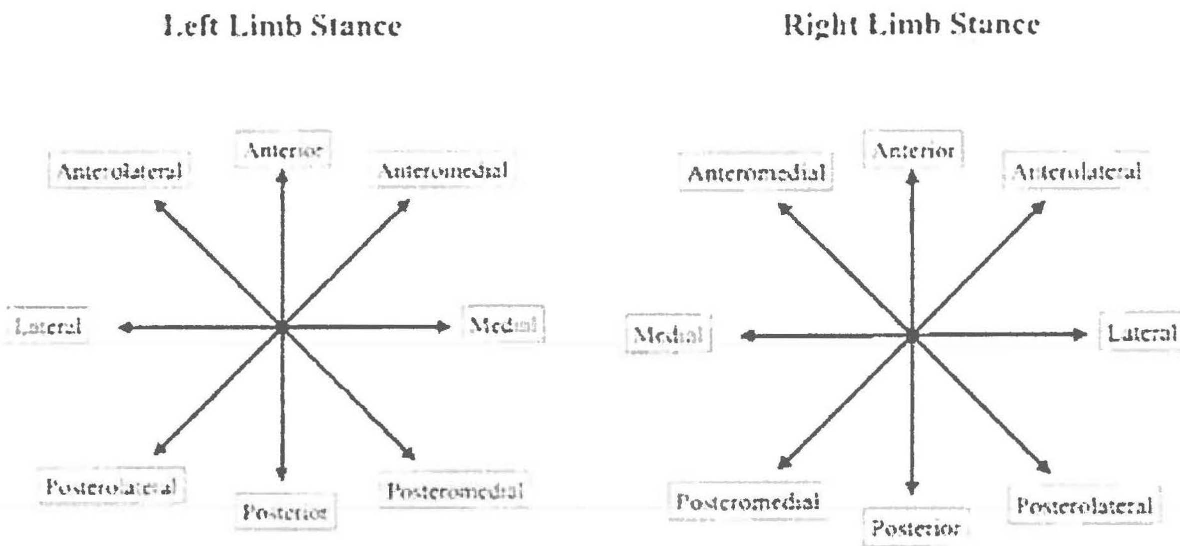


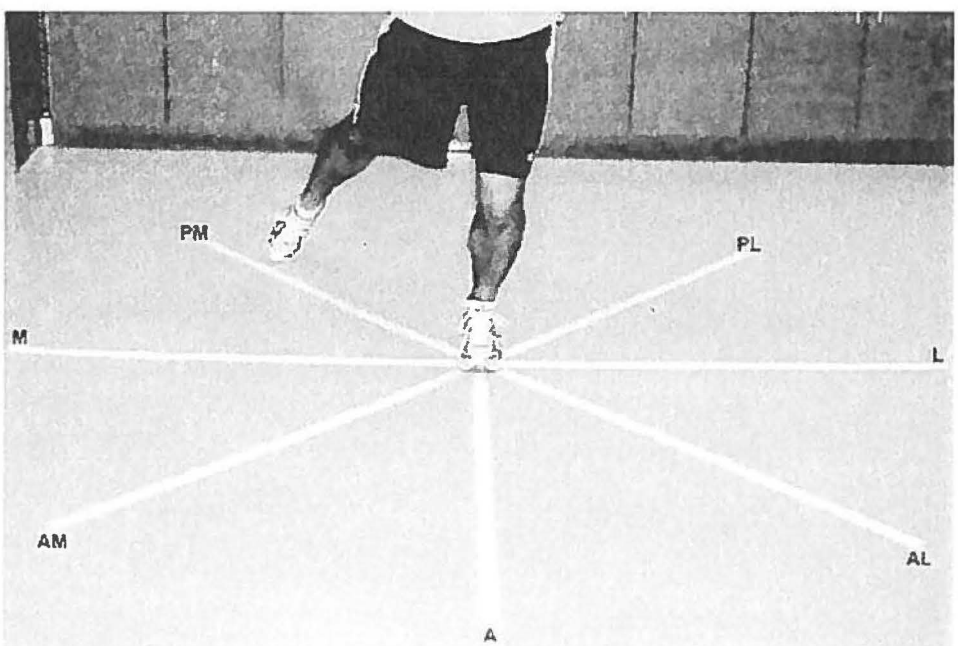
Figure A: Anterior view of the leg muscles. Figure B: Lateral view of the leg muscles

Figure C: Superficial posterior view of the leg muscles. Figure D: Deep posterior view of the leg muscle.

(Arnheim & Prentice, 2000)

Appendix D: SEBT Testing Positions





(Olmsted et al., 2002)

Appendix E: Questionnaire

Effects of ankle kinesio tape on balance questionnaire

Participant Number____________________________
Date of Test _________________________________
Starting Condition_____________________________

What was your experience using tape #1? Please explain in detail.

Would you use tape #1 in the future? Yes or No?

Why or why not?

What was your experience using tape #2? Please explain in detail.

Would you use tape #2 in the future? Yes or No?

Why or why not?

What was your experience with no tape? Please explain in detail.

Rank the condition that you believe was the most effective, #1, #2 or the no tape condition?

1.

2.

3.

Explain why?

Appendix F: Recruitment Letter

Dear potential participants,

I am writing to let you know about an opportunity to participate in a research study about the effect of ankle kinesio tape on single leg balance and athletes' perceptions of its effectiveness. This study is being conducted by myself at Adams State University. Each participant will be tested under three conditions: control (no tape), kinesio tape, and placebo tape. Participants will partake in a Star Excursion Balance Test (SEBT), which is a dynamic single leg balance test under all three conditions. Once done with all three conditions, each participant will fill out a structured, open-ended questionnaire about the athlete's perceptions on the tape conditions. The SEBT and questionnaire will take place in the Doctor's Office, within the Athletic Training Room located in Plachy hall. Total participation time for the entire study will take approximately 45 minutes to an hour. Only 1 testing session is required for this study. By participating in this study, you may find an effective aid to improve your balance, potentially improving performance. Also you will be contributing to the advancement of future research. Although rare, kinesio tape or the placebo tape may cause a skin irritation resulting in allergic reaction or rash. In case this happens, the researcher, a certified athletic trainer will take the appropriate measures to resolve the issue.

If you are interested in partaking in this study or have any questions please feel free email me at nicholsdt@grizzlies.adams.edu or by phone at 503-779-9322.

Thanks,
Derek Nichols, BS, ATC

Appendix G: IRB

Adams State University

Request to obtain approval for the use of human participants

Date: November 29th, 2015

To: Beth Bonnstetter
ASC Institutional Review Board
bbonnstetter@adams.edu
(719)-587-7494

From: Derek Nichols

Subject:

(a) Responsible Faculty Member: Brian Zuleger at brianzuleger@adams.edu

(b) Others in Contact with Human Participants: I will be the only one in contact with the participants.

(c) The title of the research: The Effect of ankle kinesio tape on single leg balance and athletes' perceptions of its effectiveness.

(d) Objectives of the research: The purpose of this study is to determine if an application of kinesio tape to the ankle is an effective measure in aiding balance using a dynamic measure of balance, the star excursion balance test (SEBT). A structured open-ended questionnaire will also be administered to determine if participants believe the kinesio tape actually worked or if it is merely a placebo effect.

(e) Methods of procedure: This research will use a randomized, controlled crossover, single blind repeated measures design in both quantitative and qualitative measures. Participants in this study will be chosen from the 2015-2016 Adams State Men's and Women's Soccer, Baseball, and Women's Lacrosse teams. Each participant will be tested under three conditions: control (no tape), kinesio tape, placebo tape. Participants will partake in six practice trials of the Star Excursion Balance Test (SEBT). Once complete they will perform the three trials of the SEBT under one of the three conditions. After completion following the same procedure will perform the SEBT under the next two conditions. Once done with all three conditions, each participants will fill out a structured, open-ended questionnaire about the athlete's perceptions on the tape conditions. The SEBT results will be analyzed using a repeated measures multivariate analysis of variance (ANOVA) though SPSS version 23 (IBM corp., 2013). Each questionnaire will be analyzed by the researcher using line by line coding, finding themes from each line. These themes will be combined into general themes, followed by the general themes being combined into emergent themes to configure the overall themes from the study on the perceived perceptions the athletes had on the effectiveness if any for the different types of tape on their balance. The SEBT and questionnaire will take place in the Doctor's Office, within the Athletic Training Room located in Plachy hall.

(f) **Protection Measures**: Participation is completely voluntary and can stop at any time. All results of the SEBT, questionnaire, and names of the participants will remain confidential. All results from the SEBT and questionnaire will be kept in a locked filling cabinet and within a pass coded protected computer in a locked office within the Athletic Training Room, which the researcher will only have access to.

(g) **Consent:** Each participant will be asked to read and sign a constent form prior to completion of the study.

(h) **Changes**: If any procedures or methods change throughout the study, I will bring it to the IRBs attention.

Name and Signature of Department Chair or Appropriate Person — Date: 3/4/16

Name and Signature of IRB chair — Date: 3/9/16

3/9/16
3/9/17

RESEARCH PARTICIPANT CONSENT FORM

The Effect of Ankle Kinesio Tape on Single Leg Balance and Athletes' Perceptions of its Effectiveness

Derek Nichols
Adams State University
Department of Human Performance & Physical Education

Purpose of Research: The purpose of this study is to determine if an application of kinesio tape to the ankle compared to a placebo or no tape is an effective measure in aiding balance.

Procedures: This research will use a randomized, controlled crossover, single blind repeated measures design in both quantitative and qualitative measures. Each participant will be tested under three conditions: control (no tape), kinesio tape, placebo tape. Participants will partake in six practice trials of the Star Excursion Balance Test (SEBT). Once completed you will perform the three trials of the SEBT under one of the three conditions. After completion following the same procedure you will perform the SEBT under the next two conditions. Once done with all three conditions, you will fill out a structured, open-ended questionnaire about the perceptions you had on the tape conditions. The SEBT and questionnaire will take place in the Doctor's Office, within the Athletic Training Room located in Plachy hall.

Duration of Participation: Total participation time for the entire study will take approximately 45 minutes to an hour. Only one testing session is required for this study.

Benefits: By participating in this study, participants may find an effective aid to improve their balance. Also you will be contributing to the advancement of future research.

Risks to the Individual: Although rare, kinesio tape or the placebo tape may cause a skin irritation resulting in an allergic reaction or rash. In case this happens, the researcher, a certified athletic trainer will take the appropriate measures to resolve the issue.

Confidentiality: All information received in this study is confidential. No names will be used during the study, as your results will be linked to a number. Participation is completely voluntary and you can stop at any time, without penalty. All results from the SEBT and questionnaire will be kept in a locked filing cabinet and within a pass coded protected computer in a locked office within the Athletic Training Room, which the researcher will only have access to.

Contact Information Statement: For questions please contact the researcher Derek Nichols, IRB Chair or the Committee Chair.

Researcher

Name: Derek Nichols
Email: nicholsdt@grizzlies.adams.edu
Phone: 503-779-9322

IRB Chair
Name: Beth Bonnstetter
Email: bbonnstetter@adams.edu
Phone: 719-587-7494

Committee Chair
Name: Tracey Robinson
Email: tlrobins@adams.edu
Phone: 719-587-7663

Voluntary Nature of Participation: I am aware that I can withdraw my participation at any time and will not suffer a penalty for doing so.

I HAVE HAD THE OPPORTUNITY TO READ THIS CONSENT FORM, ASK QUESTIONS ABOUT THE RESEARCH PROJECT AND AM PREPARED TO PARTICIPATE IN THIS PROJECT.

______________________________ ______________
Participant's Signature Date

____
Participant's Name

______________________________ ______________
Researcher's Signature Date

3/9/16
3/9/17

Appendix H: SEBT Score Card

Participant Number____________________________
Date of Test ________________________________
Starting Condition____________________________
Height_________Weight _____________Age________Gender_____
Sport_____________________

Leg Length (cm)	

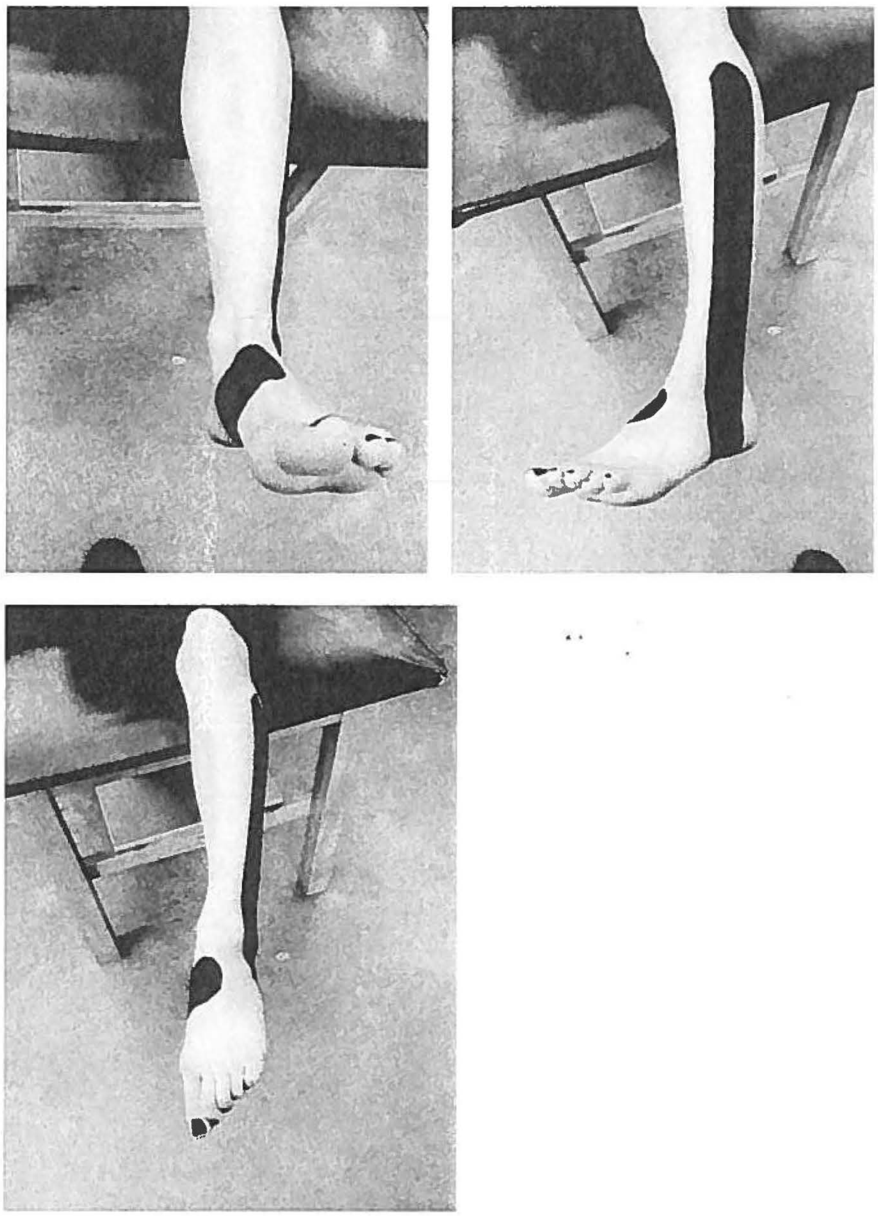
Kinesio Tape	Trial 1	Trial 2	Trial 3	Average
Anterior				
Anterior Lateral				
Lateral				
Posterior Lateral				
Posterior				
Posterior Medial				
Medial				
Anterior Medial				
			Sum	

Placebo Tape	Trial 1	Trial 2	Trial 3	Average
Anterior				
Anterior Lateral				
Lateral				
Posterior Lateral				
Posterior				
Posterior Medial				
Medial				
Anterior Medial				
			Sum	

Control (no tape)	Trial 1	Trial 2	Trial 3	Average
Anterior				
Anterior Lateral				
Lateral				
Posterior Lateral				
Posterior				
Posterior Medial				
Medial				
Anterior Medial				
			Sum	

Appendix I: Tape Application Model

Tape placement for both kinesio tape and placebo tape conditions.



(Kase, 2006)

Appendix J: SPSS Outputs

Between-Subjects Factors

		N
Cond	KT	20
	NT	20
	PT	20

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.996	1323.385[b]	9.000	49.000	.000
	Wilks' Lambda	.004	1323.385[b]	9.000	49.000	.000
	Hotelling's Trace	243.071	1323.385[b]	9.000	49.000	.000
	Roy's Largest Root	243.071	1323.385[b]	9.000	49.000	.000
Cond	Pillai's Trace	.163	.494	18.000	100.000	.955
	Wilks' Lambda	.841	.492[b]	18.000	98.000	.956
	Hotelling's Trace	.184	.490	18.000	96.000	.957
	Roy's Largest Root	.150	.832[c]	9.000	50.000	.590

a. Design: Intercept + Cond

b. Exact statistic

c. The statistic is an upper bound on F that yields a lower bound on the significance level.

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Anterior	49.844[a]	2	24.922	.427	.654
	Anterior_Lateral	85.736[b]	2	42.868	.477	.623
	Lateral	114.325[c]	2	57.163	.415	.662
	Posterior_Lateral	31.023[d]	2	15.511	.121	.886
	Posterior	4.196[e]	2	2.098	.018	.982
	Posterior_medial	10.536[f]	2	5.268	.059	.943
	Medial	6.556[g]	2	3.278	.049	.952
	Anterior_Medial	.771[h]	2	.385	.007	.993

	Sum	1498.783	2	749.391	.201	.818
Intercept	Anterior	412361.180	1	412361.180	7068.740	.000
	Anterior_Lateral	322377.798	1	322377.798	3584.190	.000
	Lateral	365594.010	1	365594.010	2656.155	.000
	Posterior_Lateral	526037.685	1	526037.685	4094.503	.000
	Posterior	606433.152	1	606433.152	5193.197	.000
	Posterior_medial	621983.762	1	621983.762	6975.449	.000
	Medial	577797.291	1	577797.291	8677.075	.000
	Anterior_Medial	486005.400	1	486005.400	8669.920	.000
	Sum	30964074.523	1	30964074.523	8310.657	.000
Cond	Anterior	49.844	2	24.922	.427	.654
	Anterior_Lateral	85.736	2	42.868	.477	.623
	Lateral	114.325	2	57.163	.415	.662
	Posterior_Lateral	31.023	2	15.511	.121	.886
	Posterior	4.196	2	2.098	.018	.982
	Posterior_medial	10.536	2	5.268	.059	.943
	Medial	6.556	2	3.278	.049	.952
	Anterior_Medial	.771	2	.385	.007	.993
	Sum	1498.783	2	749.391	.201	.818
Error	Anterior	3325.145	57	58.336		
	Anterior_Lateral	5126.831	57	89.944		
	Lateral	7845.498	57	137.640		
	Posterior_Lateral	7323.026	57	128.474		
	Posterior	6656.148	57	116.775		
	Posterior_medial	5082.551	57	89.168		
	Medial	3795.570	57	66.589		
	Anterior_Medial	3195.221	57	56.057		
	Sum	212372.172	57	3725.828		
Total	Anterior	415736.169	60			
	Anterior_Lateral	327590.365	60			
	Lateral	373553.833	60			
	Posterior_Lateral	533391.733	60			
	Posterior	613093.496	60			
	Posterior_medial	627076.850	60			
	Medial	581599.417	60			
	Anterior_Medial	489201.392	60			

	Sum	31177945.479	60			
Corrected Total	Anterior	3374.989	59			
	Anterior_Lateral	5212.567	59			
	Lateral	7959.823	59			
	Posterior_Lateral	7354.049	59			
	Posterior	6660.343	59			
	Posterior_medial	5093.087	59			
	Medial	3802.126	59			
	Anterior_Medial	3195.992	59			
	Sum	213870.955	59			

a. R Squared = .015 (Adjusted R Squared = -.020)
b. R Squared = .016 (Adjusted R Squared = -.018)
c. R Squared = .014 (Adjusted R Squared = -.020)
d. R Squared = .004 (Adjusted R Squared = -.031)
e. R Squared = .001 (Adjusted R Squared = -.034)
f. R Squared = .002 (Adjusted R Squared = -.033)
g. R Squared = .002 (Adjusted R Squared = -.033)
h. R Squared = .000 (Adjusted R Squared = -.035)
i. R Squared = .007 (Adjusted R Squared = -.028)

Multiple Comparisons

Dependent Variable		(I) Cond	(J) Cond	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Anterior	Tukey HSD	KT	NT	-.3540	2.41528	.988	-6.1662	5.4582
			PT	1.7320	2.41528	.754	-4.0802	7.5442
		NT	KT	.3540	2.41528	.988	-5.4582	6.1662
			PT	2.0860	2.41528	.665	-3.7262	7.8982
		PT	KT	-1.7320	2.41528	.754	-7.5442	4.0802
			NT	-2.0860	2.41528	.665	-7.8982	3.7262
	Bonferroni	KT	NT	-.3540	2.41528	1.000	-6.3117	5.6037
			PT	1.7320	2.41528	1.000	-4.2257	7.6897
		NT	KT	.3540	2.41528	1.000	-5.6037	6.3117
			PT	2.0860	2.41528	1.000	-3.8717	8.0437

		PT	KT	-1.7320	2.41528	1.000	-7.6897	4.2257
			NT	-2.0860	2.41528	1.000	-8.0437	3.8717
	Games-Howell	KT	NT	-.3540	2.46229	.989	-6.3593	5.6513
			PT	1.7320	2.37255	.747	-4.0547	7.5187
		NT	KT	.3540	2.46229	.989	-5.6513	6.3593
			PT	2.0860	2.41016	.665	-3.7933	7.9653
		PT	KT	-1.7320	2.37255	.747	-7.5187	4.0547
			NT	-2.0860	2.41016	.665	-7.9653	3.7933
Anterior_Lateral	Tukey HSD	KT	NT	.3895	2.99907	.991	-6.8275	7.6065
			PT	2.7080	2.99907	.641	-4.5090	9.9250
		NT	KT	-.3895	2.99907	.991	-7.6065	6.8275
			PT	2.3185	2.99907	.721	-4.8985	9.5355
		PT	KT	-2.7080	2.99907	.641	-9.9250	4.5090
			NT	-2.3185	2.99907	.721	-9.5355	4.8985
	Bonferroni	KT	NT	.3895	2.99907	1.000	-7.0083	7.7873
			PT	2.7080	2.99907	1.000	-4.6898	10.1058
		NT	KT	-.3895	2.99907	1.000	-7.7873	7.0083
			PT	2.3185	2.99907	1.000	-5.0793	9.7163
		PT	KT	-2.7080	2.99907	1.000	-10.1058	4.6898
			NT	-2.3185	2.99907	1.000	-9.7163	5.0793
	Games-Howell	KT	NT	.3895	3.10379	.991	-7.1864	7.9654
			PT	2.7080	2.82584	.607	-4.1840	9.6000
		NT	KT	-.3895	3.10379	.991	-7.9654	7.1864
			PT	2.3185	3.06013	.731	-5.1540	9.7910
		PT	KT	-2.7080	2.82584	.607	-9.6000	4.1840
			NT	-2.3185	3.06013	.731	-9.7910	5.1540
Lateral	Tukey HSD	KT	NT	-2.0630	3.70999	.844	-10.9908	6.8648
			PT	1.2885	3.70999	.936	-7.6393	10.2163
		NT	KT	2.0630	3.70999	.844	-6.8648	10.9908
			PT	3.3515	3.70999	.640	-5.5763	12.2793
		PT	KT	-1.2885	3.70999	.936	-10.2163	7.6393
			NT	-3.3515	3.70999	.640	-12.2793	5.5763
	Bonferroni	KT	NT	-2.0630	3.70999	1.000	-11.2144	7.0884
			PT	1.2885	3.70999	1.000	-7.8629	10.4399
		NT	KT	2.0630	3.70999	1.000	-7.0884	11.2144

			PT	3.3515	3.70999	1.000	-5.7999	12.5029
		PT	KT	-1.2885	3.70999	1.000	-10.4399	7.8629
			NT	-3.3515	3.70999	1.000	-12.5029	5.7999
	Games-Howell	KT	NT	-2.0630	3.57209	.833	-10.7781	6.6521
			PT	1.2885	3.69279	.935	-7.7265	10.3035
		NT	KT	2.0630	3.57209	.833	-6.6521	10.7781
			PT	3.3515	3.85947	.663	-6.0624	12.7654
		PT	KT	-1.2885	3.69279	.935	-10.3035	7.7265
			NT	-3.3515	3.85947	.663	-12.7654	6.0624
Posterior_Lateral	Tukey HSD	KT	NT	-.6425	3.58433	.982	-9.2679	7.9829
			PT	1.0990	3.58433	.950	-7.5264	9.7244
		NT	KT	.6425	3.58433	.982	-7.9829	9.2679
			PT	1.7415	3.58433	.878	-6.8839	10.3669
		PT	KT	-1.0990	3.58433	.950	-9.7244	7.5264
			NT	-1.7415	3.58433	.878	-10.3669	6.8839
	Bonferroni	KT	NT	-.6425	3.58433	1.000	-9.4839	8.1989
			PT	1.0990	3.58433	1.000	-7.7424	9.9404
		NT	KT	.6425	3.58433	1.000	-8.1989	9.4839
			PT	1.7415	3.58433	1.000	-7.0999	10.5829
		PT	KT	-1.0990	3.58433	1.000	-9.9404	7.7424
			NT	-1.7415	3.58433	1.000	-10.5829	7.0999
	Games-Howell	KT	NT	-.6425	3.34827	.980	-8.8125	7.5275
			PT	1.0990	3.78101	.955	-8.1283	10.3263
		NT	KT	.6425	3.34827	.980	-7.5275	8.8125
			PT	1.7415	3.61044	.880	-7.0837	10.5667
		PT	KT	-1.0990	3.78101	.955	-10.3263	8.1283
			NT	-1.7415	3.61044	.880	-10.5667	7.0837
Posterior	Tukey HSD	KT	NT	-.5410	3.41723	.986	-8.7643	7.6823
			PT	.0380	3.41723	1.000	-8.1853	8.2613
		NT	KT	.5410	3.41723	.986	-7.6823	8.7643
			PT	.5790	3.41723	.984	-7.6443	8.8023
		PT	KT	-.0380	3.41723	1.000	-8.2613	8.1853
			NT	-.5790	3.41723	.984	-8.8023	7.6443
	Bonferroni	KT	NT	-.5410	3.41723	1.000	-8.9702	7.8882
			PT	.0380	3.41723	1.000	-8.3912	8.4672

		NT	KT	.5410	3.41723	1.000	-7.8882	8.9702
			PT	.5790	3.41723	1.000	-7.8502	9.0082
		PT	KT	-.0380	3.41723	1.000	-8.4672	8.3912
			NT	-.5790	3.41723	1.000	-9.0082	7.8502
	Games-Howell	KT	NT	-.5410	3.30527	.985	-8.6027	7.5207
			PT	.0380	3.50756	1.000	-8.5181	8.5941
		NT	KT	.5410	3.30527	.985	-7.5207	8.6027
			PT	.5790	3.43578	.984	-7.8049	8.9629
		PT	KT	-.0380	3.50756	1.000	-8.5941	8.5181
			NT	-.5790	3.43578	.984	-8.9629	7.8049
Posterior_medial	Tukey HSD	KT	NT	-.7855	2.98609	.963	-7.9713	6.4003
			PT	.1795	2.98609	.998	-7.0063	7.3653
		NT	KT	.7855	2.98609	.963	-6.4003	7.9713
			PT	.9650	2.98609	.944	-6.2208	8.1508
		PT	KT	-.1795	2.98609	.998	-7.3653	7.0063
			NT	-.9650	2.98609	.944	-8.1508	6.2208
	Bonferroni	KT	NT	-.7855	2.98609	1.000	-8.1513	6.5803
			PT	.1795	2.98609	1.000	-7.1863	7.5453
		NT	KT	.7855	2.98609	1.000	-6.5803	8.1513
			PT	.9650	2.98609	1.000	-6.4008	8.3308
		PT	KT	-.1795	2.98609	1.000	-7.5453	7.1863
			NT	-.9650	2.98609	1.000	-8.3308	6.4008
	Games-Howell	KT	NT	-.7855	2.96103	.962	-8.0089	6.4379
			PT	.1795	3.05763	.998	-7.2776	7.6366
		NT	KT	.7855	2.96103	.962	-6.4379	8.0089
			PT	.9650	2.93827	.942	-6.2022	8.1322
		PT	KT	-.1795	3.05763	.998	-7.6366	7.2776
			NT	-.9650	2.93827	.942	-8.1322	6.2022
Medial	Tukey HSD	KT	NT	-.3665	2.58048	.989	-6.5762	5.8432
			PT	.4420	2.58048	.984	-5.7677	6.6517
		NT	KT	.3665	2.58048	.989	-5.8432	6.5762
			PT	.8085	2.58048	.947	-5.4012	7.0182
		PT	KT	-.4420	2.58048	.984	-6.6517	5.7677
			NT	-.8085	2.58048	.947	-7.0182	5.4012

	Bonferroni	KT	NT	-.3665	2.58048	1.000	-6.7317	5.9987
			PT	.4420	2.58048	1.000	-5.9232	6.8072
		NT	KT	.3665	2.58048	1.000	-5.9987	6.7317
			PT	.8085	2.58048	1.000	-5.5567	7.1737
		PT	KT	-.4420	2.58048	1.000	-6.8072	5.9232
			NT	-.8085	2.58048	1.000	-7.1737	5.5567
	Games-Howell	KT	NT	-.3665	2.46518	.988	-6.3788	5.6458
			PT	.4420	2.62118	.984	-5.9555	6.8395
		NT	KT	.3665	2.46518	.988	-5.6458	6.3788
			PT	.8085	2.65123	.950	-5.6607	7.2777
		PT	KT	-.4420	2.62118	.984	-6.8395	5.9555
			NT	-.8085	2.65123	.950	-7.2777	5.6607
Anterior_Medial	Tukey HSD	KT	NT	.0170	2.36763	1.000	-5.6805	5.7145
			PT	.2485	2.36763	.994	-5.4490	5.9460
		NT	KT	-.0170	2.36763	1.000	-5.7145	5.6805
			PT	.2315	2.36763	.995	-5.4660	5.9290
		PT	KT	-.2485	2.36763	.994	-5.9460	5.4490
			NT	-.2315	2.36763	.995	-5.9290	5.4660
	Bonferroni	KT	NT	.0170	2.36763	1.000	-5.8232	5.8572
			PT	.2485	2.36763	1.000	-5.5917	6.0887
		NT	KT	-.0170	2.36763	1.000	-5.8572	5.8232
			PT	.2315	2.36763	1.000	-5.6087	6.0717
		PT	KT	-.2485	2.36763	1.000	-6.0887	5.5917
			NT	-.2315	2.36763	1.000	-6.0717	5.6087
	Games-Howell	KT	NT	.0170	2.31343	1.000	-5.6333	5.6673
			PT	.2485	2.28546	.994	-5.3319	5.8289
		NT	KT	-.0170	2.31343	1.000	-5.6673	5.6333
			PT	.2315	2.49833	.995	-5.8616	6.3246
		PT	KT	-.2485	2.28546	.994	-5.8289	5.3319
			NT	-.2315	2.49833	.995	-6.3246	5.8616
Sum	Tukey HSD	KT	NT	-4.3445	19.30240	.972	-50.7942	42.1052
			PT	7.7400	19.30240	.915	-38.7097	54.1897
		NT	KT	4.3445	19.30240	.972	-42.1052	50.7942

		PT	12.0845	19.30240	.806	-34.3652	58.5342
	PT	KT	-7.7400	19.30240	.915	-54.1897	38.7097
		NT	-12.0845	19.30240	.806	-58.5342	34.3652
Bonferroni	KT	NT	-4.3445	19.30240	1.000	-51.9575	43.2685
		PT	7.7400	19.30240	1.000	-39.8730	55.3530
	NT	KT	4.3445	19.30240	1.000	-43.2685	51.9575
		PT	12.0845	19.30240	1.000	-35.5285	59.6975
	PT	KT	-7.7400	19.30240	1.000	-55.3530	39.8730
		NT	-12.0845	19.30240	1.000	-59.6975	35.5285
Games-Howell	KT	NT	-4.3445	18.44500	.970	-49.3332	40.6442
		PT	7.7400	19.49897	.917	-39.8579	55.3379
	NT	KT	4.3445	18.44500	.970	-40.6442	49.3332
		PT	12.0845	19.93289	.818	-36.5482	60.7172
	PT	KT	-7.7400	19.49897	.917	-55.3379	39.8579
		NT	-12.0845	19.93289	.818	-60.7172	36.5482

Based on observed means.

The error term is Mean Square(Error) = 3725.828.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation

Anterior	60	67.92	94.39	82.9017	7.56328
Anterior_Lateral	60	51.21	90.85	73.3005	9.39939
Lateral	60	53.95	99.62	78.0592	11.61517
Posterior_Lateral	60	72.00	115.92	93.6338	11.16445
Posterior	60	78.33	127.03	100.5347	10.62484
Posterior_medial	60	79.00	120.74	101.8155	9.29104
Medial	60	80.46	115.56	98.1323	8.02763
Anterior_Medial	60	74.33	100.74	90.0005	7.35998
Sum	60	600.01	825.56	718.3787	60.20740
Valid N (listwise)	60				

Report

Cond		Anterior	Anterior_Lateral	Lateral	Posterior_Lateral	Posterior	Posterior_medial	Medial	Anterior_Medial	Sum
KT	Mean	83.3610	74.3330	77.8010	93.7860	100.3670	101.6135	98.1575	90.0890	719.5105
	N	20	20	20	20	20	20	20	20	20
	Std. Deviation	7.67006	9.08541	10.72429	11.16765	10.68792	9.73825	7.69328	6.58304	56.84257
NT	Mean	83.7150	73.9435	79.8640	94.4285	100.9080	102.3990	98.5240	90.0720	723.8550
	N	20	20	20	20	20	20	20	20	20
	Std. Deviation	7.90111	10.49409	11.84003	9.97503	10.21100	8.97334	7.89655	7.98140	59.77696
PT	Mean	81.6290	71.6250	76.5125	92.6870	100.3290	101.4340	97.7155	89.8405	711.7705
	N	20	20	20	20	20	20	20	20	20
	Std. Deviation	7.33145	8.78422	12.55883	12.69664	11.48161	9.59939	8.84448	7.81859	66.12958
Total	Mean	82.9017	73.3005	78.0592	93.6338	100.5347	101.8155	98.1323	90.0005	718.3787
	N	60	60	60	60	60	60	60	60	60
	Std. Deviation	7.56328	9.39939	11.61517	11.16445	10.62484	9.29104	8.02763	7.35998	60.20740

Within-Subjects Factors

Measure	Condition	Dependent Variable
A	1	A_KT
	2	A_PT
	3	A_NT
AL	1	AL_KT
	2	AL_PT
	3	AL_NT
L	1	L_KT
	2	L_PT
	3	L_NT
PL	1	PL_KT
	2	PL_PT
	3	PL_NT
P	1	P_KT
	2	P_PT
	3	P_NT
PM	1	PM_KT
	2	PM_PT
	3	PM_NT
M	1	M_KT
	2	M_PT
	3	M_NT
AM	1	AM_KT
	2	AM_PT
	3	AM_NT
Sum	1	Sum_KT
	2	Sum_PT
	3	Sum_NT

Descriptive Statistics

	Mean	Std. Deviation	N
A_KT	83.3610	7.67006	20
A_PT	81.6290	7.33145	20
A_NT	83.7150	7.90111	20
AL_KT	74.3330	9.08541	20
AL_PT	71.6250	8.78422	20
AL_NT	73.9435	10.49409	20
L_KT	77.8010	10.72429	20
L_PT	76.5125	12.55883	20
L_NT	79.8640	11.84003	20
PL_KT	93.7860	11.16765	20
PL_PT	92.6870	12.69664	20
PL_NT	94.4285	9.97503	20
P_KT	100.3670	10.68792	20
P_PT	100.3290	11.48161	20
P_NT	100.9080	10.21100	20
PM_KT	101.6135	9.73825	20
PM_PT	101.4340	9.59939	20
PM_NT	102.3990	8.97334	20
M_KT	98.1575	7.69328	20
M_PT	97.7155	8.84448	20
M_NT	98.5240	7.89655	20
AM_KT	90.0890	6.58304	20
AM_PT	89.8405	7.81859	20
AM_NT	90.0720	7.98140	20
Sum_KT	719.5105	56.84257	20
Sum_PT	711.7705	66.12958	20
Sum_NT	723.8550	59.77696	20

Multivariate Tests[a]

Effect			Value	F	Hypothesis df	Error df	Sig.
Between Subjects	Intercept	Pillai's Trace	.997	491.846[b]	8.000	12.000	.000
		Wilks' Lambda	.003	491.846[b]	8.000	12.000	.000
		Hotelling's Trace	327.897	491.846[b]	8.000	12.000	.000
		Roy's Largest Root	327.897	491.846[b]	8.000	12.000	.000
Within Subjects	Condition	Pillai's Trace	.796	.689[b]	17.000	3.000	.737

	Wilks' Lambda	.204	.688[b]	17.000	3.000	.737
	Hotelling's Trace	3.901	.688[b]	17.000	3.000	.737
	Roy's Largest Root	3.901	.688[b]	17.000	3.000	.737

a. Design: Intercept
Within Subjects Design: Condition
b. Exact statistic

Mauchly's Test of Sphericity[a]

Within Subjects Effect	Measure	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Condition	A	.671	7.189	2	.027	.752	.803	.500
	AL	.852	2.885	2	.236	.871	.951	.500
	L	.857	2.782	2	.249	.875	.956	.500
	PL	.883	2.249	2	.325	.895	.982	.500
	P	.929	1.316	2	.518	.934	1.000	.500
	PM	.886	2.181	2	.336	.898	.985	.500
	M	.818	3.612	2	.164	.846	.920	.500
	AM	.631	8.286	2	.016	.730	.776	.500
	Sum	.477	13.329	2	.001	.657	.686	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. Design: Intercept
Within Subjects Design: Condition
b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Multivariate[a,b]

Within Subjects Effect		Value	F	Hypothesis df	Error df	Sig.
Condition	Pillai's Trace	.505	1.164	18.000	62.000	.318
	Wilks' Lambda	.541	1.197[c]	18.000	60.000	.293
	Hotelling's Trace	.761	1.226	18.000	58.000	.272

Roy's Largest Root	.623	2.148[d]	9.000	31.000	.055

a. Design: Intercept
Within Subjects Design: Condition

b. Tests are based on averaged variables.

c. Exact statistic

d. The statistic is an upper bound on F that yields a lower bound on the significance level.

Univariate Tests

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.
Condition	A	Sphericity Assumed	49.844	2	24.922	2.358	.108
		Greenhouse-Geisser	49.844	1.505	33.128	2.358	.124
		Huynh-Feldt	49.844	1.606	31.043	2.358	.121
		Lower-bound	49.844	1.000	49.844	2.358	.141
	AL	Sphericity Assumed	85.736	2	42.868	4.804	.014
		Greenhouse-Geisser	85.736	1.742	49.217	4.804	.018
		Huynh-Feldt	85.736	1.903	45.056	4.804	.015
		Lower-bound	85.736	1.000	85.736	4.804	.041
	L	Sphericity Assumed	114.325	2	57.163	3.779	.032
		Greenhouse-Geisser	114.325	1.749	65.349	3.779	.038
		Huynh-Feldt	114.325	1.912	59.782	3.779	.034
		Lower-bound	114.325	1.000	114.325	3.779	.067
	PL	Sphericity Assumed	31.023	2	15.511	.760	.475
		Greenhouse-Geisser	31.023	1.790	17.333	.760	.462
		Huynh-Feldt	31.023	1.964	15.798	.760	.472
		Lower-bound	31.023	1.000	31.023	.760	.394
	P	Sphericity Assumed	4.196	2	2.098	.159	.853
		Greenhouse-Geisser	4.196	1.868	2.246	.159	.839
		Huynh-Feldt	4.196	2.000	2.098	.159	.853
		Lower-bound	4.196	1.000	4.196	.159	.694
	PM	Sphericity Assumed	10.536	2	5.268	.442	.646
		Greenhouse-Geisser	10.536	1.795	5.869	.442	.625
		Huynh-Feldt	10.536	1.971	5.347	.442	.643
		Lower-bound	10.536	1.000	10.536	.442	.514

	M	Sphericity Assumed	6.556	2	3.278	.382	.685
		Greenhouse-Geisser	6.556	1.692	3.874	.382	.651
		Huynh-Feldt	6.556	1.840	3.563	.382	.668
		Lower-bound	6.556	1.000	6.556	.382	.544
	AM	Sphericity Assumed	.771	2	.385	.045	.956
		Greenhouse-Geisser	.771	1.461	.528	.045	.911
		Huynh-Feldt	.771	1.552	.497	.045	.921
		Lower-bound	.771	1.000	.771	.045	.834
	Sum	Sphericity Assumed	1498.783	2	749.391	1.881	.166
		Greenhouse-Geisser	1498.783	1.313	1141.410	1.881	.182
		Huynh-Feldt	1498.783	1.372	1092.609	1.881	.180
		Lower-bound	1498.783	1.000	1498.783	1.881	.186
Error(Condition)	A	Sphericity Assumed	401.614	38	10.569		
		Greenhouse-Geisser	401.614	28.587	14.049		
		Huynh-Feldt	401.614	30.507	13.165		
		Lower-bound	401.614	19.000	21.138		
	AL	Sphericity Assumed	339.086	38	8.923		
		Greenhouse-Geisser	339.086	33.098	10.245		
		Huynh-Feldt	339.086	36.155	9.379		
		Lower-bound	339.086	19.000	17.847		
	L	Sphericity Assumed	574.870	38	15.128		
		Greenhouse-Geisser	574.870	33.240	17.295		
		Huynh-Feldt	574.870	36.335	15.822		
		Lower-bound	574.870	19.000	30.256		
	PL	Sphericity Assumed	775.282	38	20.402		
		Greenhouse-Geisser	775.282	34.006	22.799		
		Huynh-Feldt	775.282	37.310	20.779		
		Lower-bound	775.282	19.000	40.804		
	P	Sphericity Assumed	500.410	38	13.169		
		Greenhouse-Geisser	500.410	35.497	14.097		
		Huynh-Feldt	500.410	38.000	13.169		
		Lower-bound	500.410	19.000	26.337		
	PM	Sphericity Assumed	453.369	38	11.931		
		Greenhouse-Geisser	453.369	34.109	13.292		

		Huynh-Feldt	453.369	37.441	12.109		
		Lower-bound	453.369	19.000	23.862		
	M	Sphericity Assumed	326.410	38	8.590		
		Greenhouse-Geisser	326.410	32.153	10.152		
		Huynh-Feldt	326.410	34.959	9.337		
		Lower-bound	326.410	19.000	17.179		
	AM	Sphericity Assumed	322.765	38	8.494		
		Greenhouse-Geisser	322.765	27.759	11.627		
		Huynh-Feldt	322.765	29.487	10.946		
		Lower-bound	322.765	19.000	16.988		
	Sum	Sphericity Assumed	15138.413	38	398.379		
		Greenhouse-Geisser	15138.413	24.949	606.778		
		Huynh-Feldt	15138.413	26.063	580.835		
		Lower-bound	15138.413	19.000	796.759		

Tests of Within-Subjects Contrasts

Source	Measure	Condition	Type III Sum of Squares	df	Mean Square	F	Sig.
Condition	A	Linear	1.253	1	1.253	.245	.626
		Quadratic	48.590	1	48.590	3.031	.098
	AL	Linear	1.517	1	1.517	.276	.606
		Quadratic	84.219	1	84.219	6.825	.017
	L	Linear	42.560	1	42.560	3.388	.081
		Quadratic	71.765	1	71.765	4.056	.058
	PL	Linear	4.128	1	4.128	.252	.622
		Quadratic	26.895	1	26.895	1.102	.307
	P	Linear	2.927	1	2.927	.276	.606
		Quadratic	1.269	1	1.269	.081	.779
	PM	Linear	6.170	1	6.170	.668	.424
		Quadratic	4.366	1	4.366	.298	.591
	M	Linear	1.343	1	1.343	.235	.633
		Quadratic	5.213	1	5.213	.455	.508
	AM	Linear	.003	1	.003	.001	.977

		Quadratic	.768	1	.768	.057	.815
	Sum	Linear	188.747	1	188.747	1.336	.262
		Quadratic	1310.036	1	1310.036	1.999	.174
Error(Condition)	A	Linear	97.020	19	5.106		
		Quadratic	304.594	19	16.031		
	AL	Linear	104.625	19	5.507		
		Quadratic	234.461	19	12.340		
	L	Linear	238.703	19	12.563		
		Quadratic	336.167	19	17.693		
	PL	Linear	311.670	19	16.404		
		Quadratic	463.612	19	24.401		
	P	Linear	201.766	19	10.619		
		Quadratic	298.644	19	15.718		
	PM	Linear	175.419	19	9.233		
		Quadratic	277.950	19	14.629		
	M	Linear	108.568	19	5.714		
		Quadratic	217.842	19	11.465		
	AM	Linear	64.621	19	3.401		
		Quadratic	258.144	19	13.587		
	Sum	Linear	2684.484	19	141.289		
		Quadratic	12453.929	19	655.470		

Tests of Between-Subjects Effects

Transformed Variable: Average

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	A	412361.180	1	412361.180	2679.931	.000
	AL	322377.798	1	322377.798	1279.345	.000
	L	365594.010	1	365594.010	955.390	.000
	PL	526037.685	1	526037.685	1526.437	.000
	P	606433.152	1	606433.152	1871.787	.000
	PM	621983.762	1	621983.762	2552.868	.000
	M	577797.291	1	577797.291	3164.498	.000

	AM	486005.400	1	486005.400	3214.707	.000
	Sum	30964074.523	1	30964074.523	2982.843	.000
Error	A	2923.531	19	153.870		
	AL	4787.744	19	251.987		
	L	7270.628	19	382.665		
	PL	6547.744	19	344.618		
	P	6155.737	19	323.986		
	PM	4629.182	19	243.641		
	M	3469.160	19	182.587		
	AM	2872.456	19	151.182		
	Sum	197233.759	19	10380.724		

Estimates

				95% Confidence Interval	
Measure	Condition	Mean	Std. Error	Lower Bound	Upper Bound
A	1	83.361	1.715	79.771	86.951
	2	81.629	1.639	78.198	85.060
	3	83.715	1.767	80.017	87.413
AL	1	74.333	2.032	70.081	78.585
	2	71.625	1.964	67.514	75.736
	3	73.944	2.347	69.032	78.855
L	1	77.801	2.398	72.782	82.820
	2	76.513	2.808	70.635	82.390
	3	79.864	2.648	74.323	85.405
PL	1	93.786	2.497	88.559	99.013
	2	92.687	2.839	86.745	98.629
	3	94.429	2.230	89.760	99.097
P	1	100.367	2.390	95.365	105.369
	2	100.329	2.567	94.955	105.703
	3	100.908	2.283	96.129	105.687
PM	1	101.614	2.178	97.056	106.171
	2	101.434	2.146	96.941	105.927
	3	102.399	2.006	98.199	106.599
M	1	98.158	1.720	94.557	101.758

	2	97.716	1.978	93.576	101.855
	3	98.524	1.766	94.828	102.220
AM	1	90.089	1.472	87.008	93.170
	2	89.841	1.748	86.181	93.500
	3	90.072	1.785	86.337	93.807
Sum	1	719.510	12.710	692.907	746.114
	2	711.771	14.787	680.821	742.720
	3	723.855	13.367	695.879	751.831

Pairwise Comparisons

						95% Confidence Interval for Difference[b]	
Measure	(I) Condition	(J) Condition	Mean Difference (I-J)	Std. Error	Sig.[b]	Lower Bound	Upper Bound
A	1	2	1.732	1.050	.346	-1.024	4.488
		3	-.354	.715	1.000	-2.230	1.522
	2	1	-1.732	1.050	.346	-4.488	1.024
		3	-2.086	1.248	.333	-5.363	1.191
	3	1	.354	.715	1.000	-1.522	2.230
		2	2.086	1.248	.333	-1.191	5.363
AL	1	2	2.708*	1.017	.046	.039	5.377
		3	.389	.742	1.000	-1.558	2.337
	2	1	-2.708*	1.017	.046	-5.377	-.039
		3	-2.319	1.045	.117	-5.063	.426
	3	1	-.389	.742	1.000	-2.337	1.558
		2	2.319	1.045	.117	-.426	5.063
L	1	2	1.289	1.444	1.000	-2.501	5.078
		3	-2.063	1.121	.244	-5.005	.879
	2	1	-1.289	1.444	1.000	-5.078	2.501
		3	-3.352*	1.094	.019	-6.225	-.478
	3	1	2.063	1.121	.244	-.879	5.005
		2	3.352*	1.094	.019	.478	6.225
PL	1	2	1.099	1.654	1.000	-3.244	5.442
		3	-.642	1.281	1.000	-4.005	2.720

	2	1	-1.099	1.654	1.000	-5.442	3.244
		3	-1.742	1.320	.609	-5.208	1.725
	3	1	.642	1.281	1.000	-2.720	4.005
		2	1.742	1.320	.609	-1.725	5.208
P	1	2	.038	1.285	1.000	-3.336	3.412
		3	-.541	1.030	1.000	-3.246	2.164
	2	1	-.038	1.285	1.000	-3.412	3.336
		3	-.579	1.112	1.000	-3.499	2.341
	3	1	.541	1.030	1.000	-2.164	3.246
		2	.579	1.112	1.000	-2.341	3.499
PM	1	2	.180	1.260	1.000	-3.128	3.487
		3	-.785	.961	1.000	-3.308	1.737
	2	1	-.180	1.260	1.000	-3.487	3.128
		3	-.965	1.034	1.000	-3.679	1.749
	3	1	.785	.961	1.000	-1.737	3.308
		2	.965	1.034	1.000	-1.749	3.679
M	1	2	.442	.898	1.000	-1.915	2.799
		3	-.367	.756	1.000	-2.351	1.618
	2	1	-.442	.898	1.000	-2.799	1.915
		3	-.808	1.095	1.000	-3.683	2.066
	3	1	.367	.756	1.000	-1.618	2.351
		2	.808	1.095	1.000	-2.066	3.683
AM	1	2	.248	1.016	1.000	-2.419	2.916
		3	.017	.583	1.000	-1.514	1.548
	2	1	-.248	1.016	1.000	-2.916	2.419
		3	-.231	1.084	1.000	-3.078	2.615
	3	1	-.017	.583	1.000	-1.548	1.514
		2	.231	1.084	1.000	-2.615	3.078
Sum	1	2	7.740	7.997	1.000	-13.254	28.734
		3	-4.345	3.759	.786	-14.212	5.523
	2	1	-7.740	7.997	1.000	-28.734	13.254
		3	-12.084	6.436	.228	-28.980	4.811
	3	1	4.345	3.759	.786	-5.523	14.212
		2	12.084	6.436	.228	-4.811	28.980

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.
Pillai's trace	.893	.923[a]	18.000	2.000	.640
Wilks' lambda	.107	.923[a]	18.000	2.000	.640
Hotelling's trace	8.308	.923[a]	18.000	2.000	.640
Roy's largest root	8.308	.923[a]	18.000	2.000	.640

Each F tests the multivariate effect of Condition. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic