A COMPARISON OF KINESIO® TAPING METHODS FOR SUBJECTS WITH PATELLAR TENDONITIS

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Kathleen Yvette Gallais

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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SUPERVISORY COMMITTEE:

Katie J. Lyman
Chair

Kyle Hackney

Thomas A. Hanson

Approved:

April 9, 2020 — Date

Yeong Rhee — Department Chair

ABSTRACT

This project investigated the effects of Kinesio® Tape on pain, kinesiophobia, and proprioception in participants with patellar tendonitis. Thirty participants with patellar tendonitis were divided into three groups, the first received a supportive Kinesio® Tape application at the knee, the second received a facilitative application at the hip, and the third received both. A Visual Analog Score, Tampa Scale for Kinesiophobia score, and a proprioceptive score quantified through the Biodex Balance System were obtained both immediately after application, and 24 to 36 hours following. Statistically significant improvement in VAS scores and in proprioceptive ability with eyes closed 24 to 36 hours following Kinesio® Tape application was observed under all interventions. Kinesio® Tape application for pain, cause of pain and proprioception may assist patients with patellar tendonitis.

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LIST OF ABBREVIATIONS

AIIS	Anterior Inferior Iliac Spine
ANOVA	Analysis of Variance
AP	Anterior Posterior
ASIS	Anterior Superior Iliac Spine
BBS	Biodex® Balance System
DDT	Donnatelli Drop Leg Test
EMG	Electromyography
H-Reflex	Hoffman Reflex
JPS	Joint Position Sense
KPS	Kujala Pain Numerical Scale
ML	Medial Lateral
MRI	Magnetic Resonance Imaging
NPRS	Numerical Pain Rating Scale
OSI	Overall Stability Index
PFPS	Patella Femoral Pain Syndrome
PSIS	Posterior Superior Iliac Spine
Q-Angle	Quadriceps Angle
ROM	Range Of Motion
SLS	Single Leg Squats
TTDPM	Time To Detect Passive Movement
TSK	Tampa Scale of Kinesiophobia
VAS	Visual Analog Scale
VISA-A	Victorian Institute of Sport Assessment-Achilles Tendinopathy

VISA-P .... Victorian Institute of Sport Assessment- Patellar Tendinopathy

VMO .... Vastus Medialis Oblique

1. INTRODUCTION

1.1. Overview of the Problem

Patellar tendonitis is a commonly diagnosed condition in both the general and active population. It has been estimated nearly 20% of the athletic population is diagnosed with this condition, thus accounting for seven percent of general orthopedic injuries.[1,2] A combination of intrinsic and extrinsic factors increases the likelihood of developing patellar tendonitis.[2] Continual microtrauma results in the patellar tendon maintaining a state of inflammation over a period of time.[3] Patient history, physical examination, functional testing, and imaging all contribute in identification of this condition. Once diagnosed, both conservative and non-conservative options are available. Conservative treatments often include rest and rehabilitation including flexibility, isometric, eccentric and concentric strength training; other modalities such as Kinesio® Tex tape may also be utilized. Improving skeletal muscle recruitment patterns, functional movements, and kinetic chain deficits may also be important in the recovery process. Regardless of treatment, early identification and intervention is critical in limiting overall damage.

Kinesio® Tex tape has become a commonly used modality since its creation in 1973 by Dr. Kenzo Kase.[4-6] Although multiple research studies have been completed to either support or refute the effectiveness of Kinesio® Tex tape, many limitations exist, rendering its use controversial. Dr. Kase has theorized several different application parameters designed to induce different outcomes.[7] Tape applied at tension greater than 50% is thought to provide supportive effects. Whereas, application from muscle origin to insertion is thought to facilitate muscle function at tensions of less than 50%. A supportive tape application over the patellar tendon may warrant improvement in pain, function, and proprioception.[7] Theories regarding the kinetic chain indicate that facilitation of the gluteus medius may have positive effect on knee stability and proprioception.

The Biodex® Balance System (BBS) has been identified as an effective way to measure proprioception. In 20-second test increments, the platform measures time spent in the anterior-posterior (AP) plane and the medial-lateral (ML) plane, while also providing an overall stability index (OSI), which is a combination of the two. Because injury has been shown to decrease proprioceptive ability,[8,9] BSS provides a means to quantify stability.[10]

1.2. Statement of Purpose

The purpose of this study was to explore the effects Kinesio Tape has on proprioception in individuals with patellar tendonitis.

1.3. Research Questions

1. What are the with-in subject differences pre- and post- tape application as measured in the Visual Analog Scale (VAS), Tampa Scale for Kinesiophobia (TSK), and overall stability index of the Biodex Balance System?
2. What are the between group differences pre- and post- tape application as measured with the VAS, TSK and overall stability index of the Biodex Balance System?

1.4. Dependent Variables

The primary dependent variable in this study was the proprioceptive performance measured with the BBS after application of Kinesio® Tex tape at the hip, at the knee or at both the hip and knee. In addition, a 10-point VAS scale and the TSK scale was used to quantify outcome measures between groups, both before and after tape application.

1.5. Independent Variable

The independent variable in this study was the application of Kinesio® Tex tape.

1.6. Limitations

Due to multiple variables, this study was not be completed without limitations. First, participants included were those 18-50 years old, limiting the population to which final results are applicable. Second, although participants presented with patellar tendonitis, the condition varied in degree of severity which made it difficult to apply results in an individual case-by-case basis. Finally, Kinesio® Tex tape is designed to correct the causation of the injury. As we only tested the gluteus medius and the patellar tendons and their role in knee proprioception and pain, we cannot conclude that other applications would not be more beneficial for each individual. Unfortunately, these limitations are beyond the scope of this study; however, future studies may be able to alter methodologies.

1.7. Delimitations

This study was limited to the Fargo-Moorhead area located in North Dakota and Minnesota, United States, due to geographical convenience. Based on existing literature, we used the following inclusion criteria: participants must have had symptomatic patellar tendonitis lasting greater than 21 days that was tender to palpation and rated at an 80 or less out of 100 on the Victorian Institute of Sport Assessment Questionnaire for patellar tendinopathy (VISA-P scale).[11-13] Participants must have been symptomatic in the summer/fall of 2019. This study was be completed over the course of 24-36 hours due to time and resource constraints.

1.8. Assumptions

Only a few assumptions were made during this research study. First, it was assumed that participants continued with activities of daily living but avoided any particularly aggravating activities during the 24 hours between tests. It was also assumed that participants answered the VISA-P questions honestly as they pertained to their pain level at that time.

1.9. Significance of Study

Due to lack of consistent evidence regarding the use of Kinesio® Tex Tape, practitioners may be reluctant to apply it in the clinical setting. This research study was designed to identify the effect of Kinesio® Tex Tape applications on proprioception in participants with patellar tendonitis. Facilitative tape application at the hip, mechanical correction tape at the knee, and the combination of the two were all be compared to baseline testing. This data should aid clinicians in making evidence-based decisions for treatment of patients with patellar tendonitis.

1.10. Definitions

Patellar tendonitis: A chronic overuse condition of the patellar tendon, commonly aggravated by activities requiring knee extension such as jumping, landing, kicking, acceleration and deceleration.[14]

Kinesio® Tape: A therapeutic tape designed to enhance function of tissues and physiologic systems. May be applied for several purposes including muscle facilitation, muscle inhibition, mechanical support, increased proprioception, decreased pain sensation, and increased lymphatic drainage.[7]

Kinesio® Tape facilitation method: A Kinesio® Tex taping method technique applied to increase muscle activation. Tape is applied from muscle origin to insertion at approximately 15-25% of possible tension.[7]

Kinesio® Tape mechanical correction method: A Kinesio® Tex taping method applied to provide support to a structure. Tape is applied at 50-75% of possible tension in order to decrease fascial restriction, decrease pain, and/or correct movement and strength limitaitons.[7]

Biodex® Balance System: A multiaxial platform designed to measure and record a participant's ability to actively stabilize a joint in a dynamic environment. The balance system moves simultaneously 20° in anterior-posterior, and medial-lateral planes requiring maximum neuromuscular coordination.[10]

2. LITERATURE REVIEW

Knee pain is a common complaint in both the athletic and general population. Knee tendon injury as a result of overuse, or microtrauma, accounts for approximately seven percent of orthopedic injuries as reported by physicians in the United States.[1] Additionally, a 20% incidence of patellar tendonitis has been reported in the active population, deeming it one of the most common athletic injuries.[2] Several intrinsic and extrinsic factors combine to increase the likelihood of developing patellar tendonitis. Diagnosis involves a variety of tests, and several conservative and non-conservative treatment techniques may be applied.

2.1. Knee Anatomy

Being thoroughly versed in the musculoskeletal anatomy of the knee is critical to understanding biomechanics and correctly diagnosing injuries of the knee. This uniaxial joint is a complex structure comprised of multiple bones, muscles, tendons, ligaments, and other soft tissue, thus, being a site for multiple pathologies. One of the most common complaints at the knee is patellar tendonitis, a pathomechanic that impacts smooth and pain free movement.

2.1.1. Bony Anatomy

The distal femur, patella, and the proximal tibia and fibula articulate to create the structure of the knee.[15,16] The femur, or the bone within the thigh, is the longest bone in the body. At the inferior portion it separates into two convex femoral condyles (medial and lateral), which function as attachments for tendons and ligaments in addition to creating a groove for the patella to articulate, which is considered the patellofemoral joint. The relationship between the femur and the patella is unique as the posterior aspect of the patella has multiple surfaces, which are designed to perfectly glide within the condyles.[17,18] While not a weight bearing bone, the patella, referred to as the knee cap by the lay public, serves an important purpose. As the largest sesamoid bone in the body,[19] the patella allows the quadriceps tendon to cross the anterior knee and facilitates smooth frontal plane movement.[20] In addition to articulating with the patella, the femur and the tibia, or the shin bone, also articulate creating the tibiofemoral joint.[21] Two concave plateaus, the medial and lateral, create the proximal structure of the tibia, which allow the femur to rotate and glide smoothly. Finally, the fibula sits just lateral to the tibia creating the proximal tibiofibular joint. At the knee, the fibula functions primarily as an insertion for tendons and ligaments.[22]

The two primary articulations at the knee include the tibiofemoral and patellofemoral joints.[20,21] Several movements occur at the tibiofemoral joint; the most widely known being flexion and extension. Although less commonly understood and considered, a small amount of rotation takes place in the sagittal plane.[23-25] Often referred to as the "screw-home" mechanism, the tibia rotates externally during the last 15° of knee extension allowing for movement around the larger medial femoral condyle.[15,25,26] Conversely, the tibia slightly internally rotates during the first few degrees of knee flexion. This rotation is critical to knee stability during weight bearing in extension.[26] In addition, gliding also occurs at the tibiofemoral articulation. In a closed-pact position, the femur rolls anteriorly and glides posteriorly within the tibial plateaus during knee flexion. During extension, the femur rolls posteriorly while gliding anteriorly.[27]

The femur and the patella also form a unique articulation. Functioning to enhance the efficiency of knee movement and disperse stress, the patella glides within the quadriceps tendon anterior to the femoral grove.[18] When the knee is in full extension, the patella sits slightly lateral in a proximal and lateral position relative to the femoral condyles. As the knee progresses through flexion, the patella glides along the femoral grove until it arrives distal and lateral to the femoral condyles at full flexion, approximately 135°.[15,18,28] These articulations allow soft-tissue anatomy to facilitate active movement at the knee.

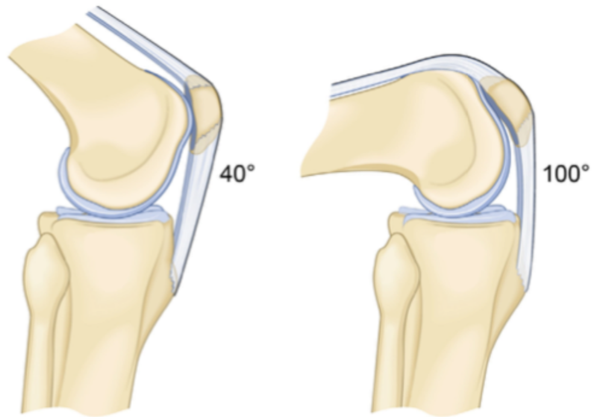

Figure 1. Patellar movement with flexion[18]

2.1.2. Soft Tissue Anatomy

Several muscle groups must function simultaneously for the knee to move and support the body. Flexion of approximately 135° and 15° of tibial rotation are a result of agonist and antagonist groups working simultaneously.[15,25] The quadriceps, hamstrings, and calf muscles are all important for active range of motion at the knee.

The quadriceps muscle group is primarily responsible for knee extension and consists of four muscles: the vastus medialis, vastus intermedius, vastus lateralis and the rectus femoris.[15,16] These four muscles converge to form the quadriceps tendon, which extends distally and envelops the patella.[20] At the distal patella the quadriceps tendon transitions to become the patellar tendon, inserting on the tibial tuberosity.[16,25] These four muscles play a critical role in knee stabilization. The bulk of the vastus medialis muscle sits distal on the thigh, and its portion of the quadriceps tendon sits on the medial side of the patella, thus making it the primary stabilizer.[29]

Opposing the quadriceps muscle group are the hamstrings, which sit on the posterior aspect of the femur and contract to flex the knee. The hamstrings include three muscles: the biceps femoris, the semimembranosus and the semitendinosus.[15,30-33] The biceps femoris contains two heads, the long and the short. The long head of the biceps femoris originates at the ischial tuberosity, while the short head of the biceps femoris originates at the linea aspera on distal third of the lateral femur.[34,35] These heads combine to insert at the fibular head. The semimembranosus and semitendinosus also originate at the ischial tuberosity and travel distally along the posteromedial aspect of the femur. The semimembranosus inserts on the posteromedial aspect of the tibial head and the semitendinosus inserts at the pes anserine at the medial tibia. In addition to completing knee flexion and hip extension, the biceps femoris muscle also externally rotates the tibia on the femur while the semimembranosus and semitendinosus participate in tibial internal rotation.[35] The sartorius and gracilis muscles also aid in knee flexion and tibial internal rotation.[34] The sartorius originates at the anterior superior iliac spine and travels distally to insert at the pes anserine at the medial tibia. Also inserting at the pes anserine, the gracilis originates at the inferior ramus of pubis. Though the gracilis primarily functions in hip adduction, it is important to note its role in knee flexion and tibial internal rotation.[36] The quadriceps and hamstring muscles are the primary agonists for movement at the knee.

Primarily tasked with ankle plantar flexion, the gastrocnemius also participates in knee flexion. The proximal gastrocnemius consists of two heads, the medial and lateral.[15] The medial head originates on the femur at the popliteal surface. The lateral head also originates at the femur, but on the posterior surface of the lateral condyle. These two heads combine distally into the Achilles tendon, which inserts at the calcaneus. Finally, the popliteus muscle also sits on the posterior side of the knee. Tasked with both knee flexion and tibial internal rotation this muscle originates at the lateral condyle of the femur and travels medially to the posterior tibia.[27]

These 12 muscles provide the knee with the ability to bear weight and move through a large range of motion. Combining to flex and extend as well as complete tibial internal and external rotation, the musculature plays a critical role in stabilization. In addition to these muscle groups directly affecting the knee, there is also research backing the relationship of the hip indirectly affecting the knee via the kinetic chain.

2.1.3. Kinetic Chain

Although the quadriceps, hamstrings, and calf muscle groups are responsible for the bulk of knee stabilization, muscles in the hips and ankles also provide support. The term kinetic chain, or kinematic chain, refers to dynamic stabilization between subsequent body segments controlled by the central nervous system.[37] When identifying and treating injuries, it is important to consider the kinetic chain and understand how strength and stability at one articulation can effect another. Conditions at the hip and ankle have been shown in some cases to have a direct impact on symptoms and functionality at the knee.[38]

Dynamic valgus at the knee has been affiliated with several knee injuries.[38-41] Quadriceps angle (Q-angle) is the angle between the intersection of lines created between the ASIS and the midpoint of the patella and the tibial tubercle to the middle of the patella.[42] Q-angle can be utilized as a measure of dynamic knee valgus with weakness at the hip and ankle being the primary causation.[40] An increased Trendelenburg sign (lateral collapsing at the hip) results in medial stress at the knee, thus increasing Q-angle.[40] While several muscles at the hip are responsible for hip abduction and external rotation, a weak gluteus medius muscle has been specifically identified as a risk factor.[42] Facilitating and strengthening this particular muscle may reduce hip internal rotation and Q-angle, subsequently decreasing possibility of knee injury.

While hip musculature plays a role in knee stability, evidence suggests that it may also be correlated with excessive subtalar pronation.[43] Weak gluteal muscles are unable to maintain the lower extremity in a neutral position, thus transferring force distally through the kinetic chain. Hip internal rotation increases likelihood of axial tibial internal rotation, which has been linked to subtalar pronation.[38,44] Kinetic chain weaknesses have also een associated with decreased neuromuscular function at the VMO further increasing susceptibility to injury at the knee.[38,41,45] Hip external rotator and abductor strength are critical in supporting the knee and ankle in a neutral position.

Gluteus medius weakness and subtalar pronation are both associated with increased risk of knee injury. When completing evaluations and developing treatment regimens, incorporation of strengthening and neuromuscular control exercises throughout the kinetic chain may be beneficial. Providing feedback and education during exercise may promote use of correct mechanics, thus preventing injury. Additionally, as a medium to decrease pain and increase muscle facilitation, Kinesio® Tape applications at various levels of the kinetic chain may provide preventive feedback or serve as a rehabilitative aid.

2.2. Patellar Tendonitis

Patellar tendonitis, often referred to as jumper's knee, is a common pathology within both the elite and non-elite active populations.[1,14,46,47] The pathology is most commonly diagnosed in people ages 16-40[1], who participate in activities requiring knee extension such as jumping, landing, kicking, acceleration and deceleration.[14] Pain associated with patellar tendonitis resides at the patellar tendon between the patella and the tibial tuberosity. Several conservative and surgical treatment options exist to control and resolve this condition.

2.2.1. Etiology

As a chronic or overuse condition, patellar tendonitis generally begins insidiously.[47] Repetitive trauma to the patellar tendon caused by forced knee extension eventually results in microlesions.[1] This trauma causes the patellar tendon to maintain an inflammatory state for a prolonged period of time.[3] Excessive inflammation leads to tendon degeneration, thus resulting in pain and increased susceptibility to further damage, including possible tendon rupture.[47,48]

Several intrinsic and extrinsic factors have been noted to increase probability of patellar tendonitis.[2] Structurally, muscle imbalance between the quadriceps and hamstring muscle group has been shown to influence tension at the patellar tendon.[2,48-50] Decreased flexibility in both muscle groups results in increased work to flex and extend the knee against this additional resistance. In addition, studies have suggested that increased adiposity,[49] patella alta,[2] patellar tendon laxity,[2] leg length discrepancy,[51] Q-angle,[52] muscle recruitment order,[51] and other malalignments[2,49,52] may also be intrinsic factors. While intrinsic factors may increase potential for development of patellar tendonitis, extrinsic factors appear to exacerbate the inflammatory process.

Extrinsic factors include type and quality of training, surfaces, equipment, and other environmental factors.[2,53] Activities that involve a large amount of jumping and landing or running often yield a greater development of patellar tendonitis.[1,49,54,55] Several studies indicate that instance of patellar tendonitis is greater in athletes who participate in volleyball, basketball, track and field, and soccer.[1,48,56] However, it is possible that activities of daily living, such as squatting, ascending and descending stairs, and sit-to-stand can also trigger symptoms.[48] Researchers also suggest that training surfaces correlate with the development of patellar tendonitis. Transitioning from a low-impact to high-impact surface, training on surface with low shock absorption, and wearing shoes with little cushioning have all been considered factors.[53] The combination of structural or intrinsic factors, and environmental or extrinsic factors have all shown to increase incidence of patellar tendonitis particularly in active individuals.

2.2.2. Diagnosis and Treatment

As patellar tendonitis is prevalent in the active population, there are several ways that this condition may be diagnosed. Clinically, patient history, physical examination, functional testing and the Victorian Institute of Sports Assessment questionnaire for patellar tendonitis (VISA-P) are often utilized. Diagnostic imaging including diagnostic ultrasound and magnetic resonance imaging (MRI) can also be conducted to both confirm and define the extent of pathology and track healing progress. Several treatment techniques may be applied depending on the severity of this condition.

A detailed history may help the clinician identify both intrinsic and extrinsic factors that indicate an instance of patellar tendonitis.[1] Complaints of anterior knee pain located between the patella and tibial tuberosity with activity involving knee flexion and extension are often indicative of this condition. Further evaluation including palpation reveals pain at the patellar tendon, often near the distal pole of the patella.[1,2,14,50,57,58] Palpation has been identified as a reliable predictor ($p < .001$) of patellar tendonitis supported by diagnostic ultrasound in patients with moderate to severe pain.[58] Additionally, single-leg functional testing such as ascending and descending stairs, hopping, landing, and squatting on a decline have been shown to indicate this condition.[1,48,51]

The VISA-P is a clinical assessment that was developed to quantify pain and functionality for activities of daily living and sport in patients.[59,60] The evaluation consists of eight questions and results in a score out of 100, with 100 indicating an asymptomatic patient. A score below 80 is an indication of patellar tendonitis in a symptomatic patient.[3] The VISA-P is a frequently used patient outcome and has developed a reputation as a valid and reliable tool to aid in the diagnosis of patellar tendonitis.[61-63]

Diagnostic ultrasound and MRI have both been utilized in detecting the pathology and tracking treatment progress in patients with patellar tendonitis.[58,64] As an affordable, non-invasive, and time efficient tool, patellar tendons are often visualized with the diagnostic ultrasound.[2,65] Pathology is detected by identifying hypoechoic areas, tendon and tendon sheath irregularities, and measuring tissue thickness.[65] Although diagnostic ultrasound has a reputation for specificity and sensitivity in confirming severe cases of patellar tendonitis, it may not be as reliable in identifying this condition in patients with mild to moderate symptoms.[2,66] While there are some limitations with diagnostic ultrasound, research does support its use over MRI.[50]

Patellar tendonitis can be managed with both conservative and non-conservative approaches. Rest and rehabilitation including flexibility, isometric, eccentric and concentric strength training are generally part of non-invasive programs.[14] Treatment with modalities such as Kinesio® Tex tape, friction massage, instrument assisted soft tissue mobilization, cryotherapy, and thermotherapy may also be incorporated.[1] Patients may progress through various stages of return-to-activity based on improvement in recruitment patterns, functional testing, and kinetic chain deficit.[48] Education in proper running, jumping and landing techniques may also reduce long-term symptoms.[48] Injection of corticosteroids is not uncommon if symptoms persist.[60] Surgical intervention may also be necessary in severe cases where conservative treatment is ineffective. An arthroscopic resection of debris and some of the inflamed tissue at the distal patellar tendon is a common technique.[14,67]

Early recognition and diagnosis of patellar tendonitis is important in limiting the severity of the condition. As this condition worsens, it can potentially result in irreversible tissue degeneration. In extreme cases, patellar tendonitis can significantly affect quality of life and physical activity, and even be career ending for some athletes.[48]

2.3. Kinesiology Tape

Kinesio® Tape was invented in 1973 by Dr. Kenzo Kase, a Japanese chiropractor. Popularity of this colored tape and intricate applications have increased since its appearance at the 2008 Olympic Games in Beijing, China.[4-6,68] In addition to creation of Kinesio® Tape, Dr. Kase developed application techniques designed specifically for his product. Tape style, tension, and application direction depend on the specific desired outcome. Kinesio® tape can be used to facilitate or inhibit muscle activity,[4,69,70] regulate pain,[4,68,70,71] and improve proprioception.[4,68,70] As a result of its reputation, several competing companies have developed tapes with similar characteristics. It is important for the clinician to understand the characteristics, strengths, and weaknesses of available kinesiology tapes in order to maximize effectiveness of applications.

2.3.1. Characteristics

Kinesio® Tape was designed with materials that work together to provide a strong but functional product. The elastic body of Kinesio® Tape is comprised of cotton and polyurethane synthetic fibers coated with a latex-free, hypoallergenic adhesive backing.[6] Kinesio® Tape can be worn for multiple days without compromising comfort or effectiveness by imitating the thickness of the epidermis.[68-70,72] Many companies claim to have designed a product similar or superior to Kinesio® Tape; however, limited research has been completed to identify material composition and to compare competing kinesiology tape products.

A textile evaluation was used to identify properties of each component of TEMTEX® kinesiology tape, a brand claiming to have derived their product specifically from Dr. Kase.[5] Researchers dissected TEMTEX® tape and examined each element to understand how it works mechanically. Yarn types, adhesive, mechanical function, porosity, air and water vapor permeability, and thermophysical properties were analyzed at a relaxed state and at 50% tension. Evaluation of yarn reveals warp yarns are cotton fibers surrounding an elastane filament, while weft yarns are entirely comprised of cotton. Due to the elastic properties of warp yarns and non-elastic properties of weft yarns, tape is able to extend up to 160% of its original length without stretching horizontally. The heat-activated, hypoallergenic adhesive applied to the back of the yarns is solely acrylic. In a relaxed state, adhesive coats 76% of the yarns thereby allowing minimal air and water vapor transportation. The area of gaps in the tape are considered pores; as the tape is stretched, the size and number of these pores increase resulting in increased surface area of non-adherence. Elongation of the kinesiology tape maximizes air and water vapor permeability, providing increased insulation as air becomes locked in the pores, and breathability as sweat can evaporate through the adhesive. Some of the analyzed characteristics may be comparable to those of Kinesio® Tex tape; however, according to Kinesio® Tex, these products have no association. Material characteristics cannot be specifically compared between the two kinesiology tapes, as a textile evaluation studying Kinesio® Tex has not been published. In addition, there are also several other brands of kinesiology tape on the market; however, similar to Kinesio® Tex tape, analysis of the material elements is not available at this time. Although there is a lack of comparison regarding textile components, there is some comparison of mechanical properties between different brands.

Mechanical properties have a significant impact to kinesiology tape outcomes; therefore, it is important for the clinician to understand strengths and weaknesses of each product. A laboratory study, similar to the previously described textile analysis,[5] compared longitudinal strength and surface adherence of five different kinesiology tape products.[6] Products chosen for analysis included: Kinesio® Tex Gold, Kinesio® Tex Gold-FP, Kinesio Sport®, RockTape®, and Premium Kinesiology 3 NS Tex®. For each tape tested, five samples were used in a traction test to identify maximum deformation, maximum load, maximum tension, and relative stiffness. To test mechanical traction, tape was anchored with two clamps and stretched at 50 millimeters per minute (mm/min) with a force of five Newtons (N), and 10 seconds (s) of accommodation. Each sample was stretched until fiber failure, then a software package, TESC 3.04®, was used to develop a graph comparing load and deformation. Of the five brands tested, Kinesio® Text Gold-FP was superior in maximum tension (301.42Pa), load (215.87N), and stiffness (5.14N/mm); however, this tape exhibited greater levels of deformation at a lesser tension than three of the four competitors (203.98%). In addition to identifying the amount of tension to reach deformation, researchers were able to identify levels of homogeneity throughout the length of the tape being tested. Homogeneity is relevant as it represents the consistency of quality throughout the tape's length. As identified through standard deviation, Premium Kinesiology 3 NS Tex® (203.98%, SD=26.84) proved to have the greatest number of inconsistencies in quality throughout the length, while Kinesio® Tex Gold-FP (225.85, SD=1.70) presented with the least.

The second half of this study compared tape adherence for the same five brands. Like the mechanical traction test, five samples of each brand were tested. Each sample was anchored between two clamps placed 10mm in front of a metal plate. Thirty millimeters of tape was adhered to the metal plate by a physician who ran their fingers across the tape three times with pressure similar to clinical application. The same physician applied each sample to ensure the greatest consistency of application. At an angle of 20 degrees, the tape was stretched at a velocity of 100mm/min until tape was completely removed from the metal plate. For the purpose of this study, researchers consider load to be the most significant representation of adherence quality. Load can be defined as the ability to adhere against the highest level of traction. Premium Kinesiology 3 NS Tex® proved to provide the greatest mean adherence (11.18N, SD=1.45), while Kinesio® Tex Gold had the lowest (4.56N, SD=0.34). In addition to highest mean adherence, Premium Kinesiology 3 NS Tex® performed best related to maximum tension (156.10Pa) and overall stiffness (0.21N/mm). This study demonstrates that even though companies may make claims regarding effectiveness of their tapes, the products are not interchangeable. Understanding the characteristics, strengths, and weaknesses of different brands can aid in making evidence-based decisions when purchasing and applying kinesiology tapes in the clinical setting.

2.3.2. Implications

2.3.2.1. Facilitation and Inhibition

Kinesiology tape has become a common intervention used for a variety of musculoskeletal and neuromuscular conditions. Multiple studies have shown that with correct application, kinesiology tape can be used to facilitate or inhibit muscle activity,[4,69,70] regulate pain,[4,68,70] and improve proprioception.[4,68,70] To produce either facilitative or inhibitory effects, tape application is both direction and tension dependent.[4,71,73] According to the Kinesio Taping Method®, applying tape from origin to insertion increases muscle activation by promoting a concentric reaction of the muscle and fascia, described as facilitation. In contrast, by applying from insertion to origin an eccentric reaction is promoted, resulting in decreased muscle activity, described as inhibition.[7] The amount of tension applied to the kinesiology tape application may also impact application results. The Kinesio Taping Method® recommends using 10-35% tension for facilitative application, and 10-25% for inhibitory applications. Researchers have completed studies attempting to prove or disprove therapeutic effects of Kinesio® Tex and the Kinesio Taping Method® with varying results.

Researchers have studied the effect of cutaneous stimulation on facilitation and inhibition of underlying musculature in a variety of ways.[71,73-75] A blinded test-retest study was used to evaluate the inhibition mechanism of an unspecified kinesiology tape on motor neuron excitability in anesthetized and non-anesthetized skin.[4] Twenty healthy, non-athletic male subjects between the ages of 20 and 35 participated in the study. Electrical stimulation was used to stimulate the sensory neurons, while electromyography captured the response of motor neurons in both the soleus and lateral gastrocnemius muscles. Prior to the experimental portion of the study, initial profiles were created for each subject identifying pulse intensity to provoke a minimum response and intensity required to provoke a Hoffman reflex (H-reflex). The H-reflex is the reaction of motor neurons following stimulation of the correlating sensory nerve. From the H-reflex intensity, 5% of the max H-reflex was calculated and defined as the threshold value. Each subject was taken through five separate experimental sessions with a period of 48 hours between each test. The five sessions include a control session with no intervention, a session where only anesthesia was applied, a session using only kinesiology tape, a session combining anesthesia and kinesiology tape, and finally a sham tape session. During each test, a 1-ms square pulse wave was sent through the tibial nerve every ten seconds, increasing intensity incrementally from the threshold level to a maximal muscle response. H-reflex recruitment curves from these tests were compared to the initial recruitment profiles. For the kinesiology taping sessions, a "Y-strip" method was applied. Anchored at the calcaneus, tape was applied proximally along the Achilles tendon and split along the medial and lateral heads of the gastrocnemius. Despite referencing the Kinesio Taping Method®, this inhibition taping technique was applied with 50-75% tension, as opposed to the recommended parameters of less than 25% tension. The same kinesiology tape "Y-strip" was used during the sham tape session; however, it was applied with no tension. An H-reflex recruitment curve was recorded prior to and following each intervention. For the anesthesia and tape session, a curve was recorded between each intervention, and for the anesthesia alone, recordings were taken 10- and 25-minutes following application.

Results between pre- and post-test conditions were compared using a repeated measures ANOVA, and H-reflexes from each session were compared using a post-hoc test with a significance level of .05. When evaluating the post-hoc tests, researchers revealed statistically significant results. As depicted in Table 1, lateral gastrocnemius H-reflex threshold was decreased (p=<.001) when comparing the control session to the tape session, indicating a facilitative effect. Similarly, during the same comparison, maximum H-reflex responses in the soleus (p=<.001) and gastrocnemius (p=.04) were also decreased. When comparing the control to the anesthesia session, significant increases in threshold and maximum H-reflexes were evident in the soleus (p= <.001 and p=.05, respectively), indicating an inhibitory effect. When combined, tape and anesthesia maintained a facilitative effect with a decrease in threshold response in the soleus (p=.03), and a decrease in maximum response in the gastrocnemius (p=.003). This result indicates the facilitatory effects of kinesiology tape are more significant than the inhibitory effects of the analgesia. Despite applying the tape from insertion to origin, facilitative effects with kinesiology tape application, and inhibitory effects with anesthesia application were consistent throughout the study. Additionally, as indicated below in Table 1, statistically relevant data were found when comparing the sham to the tape session. During three comparisons, a facilitative effect was observed in the tape session while no statistically significant effect resulted in the sham session, suggesting kinesiology tape tension has an impact at the motor neuron level.

Table 1. Control vs. Tape, Control vs. Anesthesia, Control vs. Tape-Anesthesia, Sham Tape vs. Tape.

	Control vs. Tape		Control vs. Anesthesia	
Variable	Mean Diff. (95% CI)	P Value	Mean Diff. (95% CI)	P Value
H Slope				
Sol	-0.41(-1.05-0.22)	0.1	0.39(-1.3-2.1)	.4
Gastr	-0.39(-1.09-0.30)	0.2	-0.27(-4.5-3.9)	.8
Hth (Threshold)				
Sol	-0.02(-0.05-0.00)	0.1	-0.4(-0.7-0.1)	**<.001**
Gastr	0.3(0.1-0.6)	**<.001**	-0.01(-0.06-0.02)	.3
Hmax (Max Response)				
Sol	0.2(0.1-0.4)	**<.001**	-0.3(-0.7-0.4)	**.05**
Gastr	0.3(0.0—0.7)	**0.04**	-0.05(-0.1-0.03)	.1
First Hslp				
Sol	0.55(-0.07-1.17)	0.07	-0.3(-1.6-0.9)	.6
Gastr	0.16(-0.18-1.42)	0.1	-1.3(-3.8-1.2)	.2
Hmax/Mmax Ratio				
Sol	0.15(-0.6-0.9)	0.5	0.02(-0.1-0.2)	.8
Gastr	-0.03(-0.2-0.1)	0.7	0.1(-0.4-0.8)	.1

	Control vs. Tape-Anesthesia		Sham Tape vs. Tape	
Variable	Mean Diff. (95% CI)	P Value	Mean Diff. (95% CI)	P Value
H Slope				
Sol	-0.30(-0.4-1.1)	0.4	0.68(-0.63-1.47)	1
Gastr	-0.04(-0.9-0.9)	0.9	0.51(-0.26-1.28)	.1
Hth (Threshold)				
Sol	0.4(0.0-0.8)	**0.03**	0.25(-0.09-0.5)	.08
Gastr	0.03(-0.01-0.07)	0.1	0.5(-0.2-1.1)	**.01**
Hmax (Max Response)				
Sol	0.3(-0.1-0.7)	0.07	0.61(-0.5-1.8)	0.08
Gastr	0.6(0.2-0.9)	**0.003**	0.55(0.02-1.11)	**0.03**
First Hslp				
Sol	-1.1(-3.2-0.9)	0.2	0.44(-0.07- -1.17)	**.05**
Gastr	-1.4(-4.1-1.1)	0.2	0.17(-0.2-0.51)	.32
Hmax/Mmax Ratio				
Sol	0.1(-0.5-0.8)	0.5	0.03(-0.22-0.24)	.8
Gastr	0.05(-1.2-1.3)	0.6	0.05(-0.03-0.12)	.2

Two separate studies were used to test concentric knee flexion and extension of participants' dominant leg using the Biodex® isokinetic dynamometer. These studies identify time to peak torque and peak muscle torque at 60°/s, 120°/s, and 180°/s using separate kinesiology tape applications. The first study was a cross sectional design of isokinetic knee function that utilized 30 healthy participants (14 men and 16 women; M=28.4±4.7 years).[71] A tape and a non-tape session was completed with a minimum of seven days between sessions. Prior to each test, participants completed five minutes of low intensity cycling and three practice trials with 60 seconds in-between to familiarize with the equipment. Testing range was set between 100° of knee flexion and full knee extension. For the tape session, Kinesio® Tex tape was applied with the patient supine in 30° of hip flexion, and 50° of knee flexion. Tape was anchored over the vastus medialis and applied distally with 75% tension and split to encompass the vastus medialis oblique (VMO), thereby attempting to create a facilitative effect. Credentials of the clinician completing the application were not readily available. Results of this study were analyzed using repeated measures ANOVA comparing the relationship of angular velocity with peak torque, total work done, and time to peak torque. As identified below (Table 2), data obtained indicated improvement in time to peak torque, while data did not indicate an improvement in peak torque or total work done. These results indicate that Kinesio® Tex tape does provide facilitative effects in healthy participants.

The second study, also using the Biodex®, was a single-blind, cross-over design completed to identify the effects of direction-dependent kinesiology tape applications on quadriceps strength.[73] Eighteen healthy athletes (12 men and six women) participated in this study (M=25.89±3.13 years). Subjects were randomly assigned to two groups and participated in each intervention with one week between sessions. For the facilitative taping, three "I-strip" pieces of Bio Balance® Kinesiology tape were anchored at the anterior superior iliac spine and applied distally to the superior border of the patella. One piece was applied over the vastus medialis, rectus femoris, and vastus lateralis each at 20-25% tension. The inhibition technique was applied with the same tension over the same structures; however, the direction of application was opposite of the facilitative technique. Baselines of ten repetitions of knee flexion and extension at angular velocities 60°/s, 120°/s, and 180°/s were obtained prior to experimental testing. Following baseline testing, subjects were given ten minutes to rest, the kinesiology tape application was applied, and the test was completed again. A paired t-test was used to compare quadriceps strength pre- and post-tape application, while an independent t-test was used to compare the direction-dependent results. Researchers concluded there was statistically significant improvement in peak muscle torque from the control with both taping applications as depicted below in Table 3; however, there was no significant difference when comparing the two taping techniques. When compared to the previously discussed study, it is evident that kinesiology tape may provide facilitative effects.

As previously stated, researchers revealed statistically significant improvement with kinesiology tape application while testing concentric knee flexion and extension. The study using Kinesio® Tex tape, indicated there was no statistically significant difference in peak torque with flexion and extension in both the Kinesio® Tape and non-tape conditions. However, as presented in Table 2, time to peak torque was significantly improved during extension at all three angular velocities ($p<.01$). This decrease may be a result of the facilitative taping technique applied to the extensors of the knee. Although the first study indicated that there was no difference in peak torque for either flexion or extension, the second study indicated there was indeed, a change in peak muscle torque for both movements.[71] Despite not finding results when comparing the two taping techniques, there was statistically significant improvement from the pre- to the post-test during the origin to insertion taping test in all three velocities (p=.001, p=.006, and p=.007, respectively). An increase in muscle torque was evident indicating that the Bio Balance® kinesiology tape may have increased motor neuron recruitment. This test also utilized an origin-to-insertion application technique, supporting the concept that kinesiology tapes may have an activation effect on underlying musculature. Several limitations were reported for each study including: only reviewing immediate effects of application;[71,73] a limited participant age range;[71,73] healthy, non-injured population;[73] not providing a control group;[71] and possibly having inconsistent tension with application.[71] To solidify information gathered from this data, more research should be completed on different populations, with unhealthy tissue, and over an extended period of time.

Table 2. Time to Peak Torque in Extension and Flexion[71].

Position	Velocity	Without tape	With tape	Mean difference	95% CI	P-Value
Extension						
	60°/s	618.7(121.9)	517.3(99.7)	-101.3(122.4)	-147.0--55.6	**<.01**
	120°/s	370.0(45.9)	327.7(52.2)	-42.3(41.2)	-57.7--26.9	**<.01**
	180°/s	277.0(38.3)	241.0(47.3)	-36.0(45.4)	-52.9--19.1	**<.01**
Flexion						
	60°/s	552.7(216.2)	506.3(181.8)	-46.3(184.7)	-115.3-22.6	.18
	120°/s	359.0(87.0)	401.0(141.4	-42.0(154.7)	-99.8-15.8	.15
	180°/s	319.0(102.6)	317.3(123.7)	-1.7(137.1)	-52.8-49.5	.95

Table 3. Quadriceps Peak Muscle Torque Following Bio Balance® Kinesiology Tape Application[73].

Variables	Velocity	Pre-test	Post-test	P-Value
Origin to insertion				
	60°/s	132.89±59.58	151.75±61.59	**.001**
	120°/s	114.7±53.53	126.62±51.65	**.007**
	180°/s	92.63±40.34	103.05±41.00	**.006**
Insertion to origin				
	60°/s	138.32±55.94	149.14±66.90	.016
	120°/s	113.22±49.30	119.06±49.53	.004
	180°/s	91.91±42.07	96.42±40.49	.025

In addition to the improvement in time to peak torque, kinesiology tape has also been found to impact the knee through application at the hip. Researchers have concluded that a strong relationship exists between the hip and knee; intervention at either joint consequently affects the other.[76] While research has been completed identifying the relationship between hip stability and knee pain, little information is available outlining the effects of kinesiology tape applications on this relationship. The abductors of the hip support the knee in a neutral position, preventing dynamic knee valgus. Dynamic knee valgus can be described as a combination of hip internal rotation, knee valgus, and tibial external rotation on impact. Weakness of the gluteus medius, one of the primary hip abductors, has been associated with knee injuries, particularly ACL tears and ruptures in female athletes.[77] A single-blind, randomized control trial was used to study the effects of a gluteus medius kinesiology tape application on dynamic knee valgus and abductor strength.[78] Forty healthy athletes (28 male and 12 female) participated in this study (M= 21.2±2.0 years); 20 were allocated to the control group, and 20 to the experimental group. Inclusion criteria required for participation included initial dynamic knee valgus of greater than 8 degrees in men, and greater than 13 degrees in women, and participation in collegiate athletics. Dynamic knee valgus was assessed using the drop jump test where participants were instructed to step off a 31 cm box and subsequently complete a maximum vertical jump. Drop jump testing was recorded using a video camera placed 10 m in front of the participant and analyzed by a clinician blinded to the nature of the test.[79] Despite attempting to facilitate glute medius activity, an inhibitory "Y" technique using an unspecified kinesiology tape was applied to the experimental group. For the tape application, subjects were positioned side-lying with their dominant leg in 90° of hip flexion, slight adduction and internal rotation. Tape was anchored at the head of the greater trochanter, and the anterior arm of the "Y" was applied with 15-25%

tension to the anterior superior iliac spine (ASIS). The same tension was applied to the posterior arm which was adhered proximally to the posterior superior iliac spine (PSIS). The sham tape for the control group was applied with the same location and tension, however, participants were side-lying with their hip in a neutral position. Following tape application, participants were evaluated again for dynamic knee valgus using the drop jump test previously described. The second test, the Donnatelli Drop Leg Test (DDT), was used to assess strength in the posterior portion of the gluteus medius. Participants were tested side-lying with the hip passively brought into full abduction and 20° of extension. The position was to be maintained seven to ten seconds, and a drop of two to twelve inches was indicative of weakness. Each participant was tested using the Drop Jump Test and the DDT prior to tape application, immediately following tape, and again three days following tape application. Inter-group comparison was analyzed using the Friedman and Mann Whitney U-tests, while the kinesiology tape and sham sessions were compared using an independent t-test.

Table 4. Drop Jump Test Results (° Dynamic Knee Valgus), and Donatelli Drop Leg Test (Seconds).

	Kinesiology tape (95% CI)	Sham (95% CI)	P-Value
Drop jump test			
Males			
Pre-test	11.6° (10.4-12.7)	11.1° (10.5-11.7)	.77
Post-test	7.6° (6.7-8.5)	10.6° (9.9-11.3)	**<.001**
3-day post-test	10.1° (9.1-11.2)	10.6° (9.9-11.2	.31
Females			
Pre-test	15° (14.3-15.7)	16.5° (15.4-17.6)	.026
Post-test	10.7° (9.8-11.5)	16.2° (14.6-17.7)	**.002**
3-day post-test	13.3° (12.5-14.2)	15.5° (14.4-16.6)	**.004**
DDT (both genders)			
Pre-test	2s (1.5-2.5)	2.5s (1.9-3.1)	.23
Post-test	5.7s (5.5-5.9)	2.8s (2.4-3.2)	**<.001**
3-day post-test	5.4s (4.9-5.8)	2.5 (1.9-3.1)	**<.001**

Statistically significant results were detected when analyzing the results of the Drop Jump test and the DDT. As presented in Table 5 above, immediate effects in dynamic knee valgus were observed in both the male and female participants ($p=<.001$ and $p=.002$, respectively) when comparing the kinesiology tape application to the sham application. Though the men did not demonstrate an effect after three days ($p=.31$), improvement was seen within the female population ($p=.004$). Based on the test immediately following tape application, reduction in dynamic knee valgus with the kinesiology tape application suggest this tape has immediate subcutaneous effects; however, findings from this study do not indicate strong results promoting an extended effect. Noteworthy results were also found when comparing tape applications in the DDT. Statistically significant improvement was reported in both the post-test ($p=<.001$) and the three-day post-test ($p=<.001$). This improvement indicates kinesiology tape has both a significant immediate and prolonged effect on muscle facilitation. It is also important to consider that this study did not identify significant improvement in either test with the sham taping technique. Because researchers applied the same tape, but with no tension, it can be inferred that tension is a critical component of an effective tape application. Several limitations exist within this study, perhaps the most prominent being the inhibitory taping application with the expectation of facilitative results. While researchers accomplished muscle facilitation, a different application may have been even more impactful. Other limitations also include using an unspecified kinesiology tape and solely studying a healthy athletic population. Further research should be completed utilizing different taping techniques to compare and develop consistent outcomes. Despite these limitations, this study indicates that kinesiology tape applied at the hip has a statistically significant immediate effect on dynamic knee valgus. Although specific application parameters to produce either facilitatory or inhibitory effects have been outlined by the Kinesio®

taping method, several studies have identified facilitative effects may not be direction-dependent. Additional research should be completed utilizing the correct parameters to prove or disprove this theory.

2.3.2.2. Pain Regulation

Similar to the varying results noted in the comparisons of facilitation and inhibition taping techniques, there is also controversy related to the use of kinesiology tape for pain management. While studies utilizing space correction tape application have yielded positive results,[80] applications to specifically relieve pain have not revealed consistent data. Kinesiology tape is thought to lift the skin from underlying fascia to create space below the epidermis. Theoretically, by creating subcutaneous space, pressure is released from mechanoreceptors beneath the skin, thereby reducing painful nociceptive signals. Additionally, an increase in interstitial space may also create an avenue for blood flow, which can aid in removing lymphatic fluid from an injured area, ultimately reducing pain.[70,81] Often, applications designed to reduce pain are applied from insertion to origin with the intention of producing an inhibitory effect; thereby reducing muscle dysfunction and subsequent spasm.[82] Research has been completed investigating the effectiveness of kinesiology tape for pain relief although results have been inconsistent.

A placebo-controlled, single-blinded study was completed to identify the effect of an inhibitory kinesiology tape application on subjects with active upper trapezius trigger points associated with neck and/or upper back pain.[82] Twenty subjects were randomly assigned to the test group (M=29.95± 4.9 years) while 17 were assigned to the sham (M=33.86± 8.47 years). Kinesio® Tex tape was applied to both the experimental group and the sham group. Despite utilizing a Certified Kinesio® Tape practitioner for application, tape was applied to the experimental group from insertion to origin with 100% tension, contradicting inhibitory tension parameters suggested by the Kinesio® Taping method of less than 25%. Tape was anchored at the inferior acromion and applied along the trapezius to the hairline. The sham group was taped in the same direction; however, tape was applied without tension across the shoulder. Participants returned every four days for re-application; they were instructed to keep the tape on for three days and allow one day of rest prior to re-application. Each participant was evaluated initially as a baseline, again after the tape was first applied, and finally one month following initial application. Results were measured using a visual analog scale (VAS), a pressure algometer for pain, and a dynamometer to measure muscular strength of the upper trapezius. Data comparing groups were analyzed using an independent t-test or the Mann Whitney U-test, while data within each group were compared using the Friedman Test.

Table 5. Comparison of VAS, Algometry and Trapezius Muscle Strength.

	Pre-treatment	Post-treatment	Follow-up
VAS			
Experiment	6.86±1.87	3.86±2.60	2.64±3.25
Sham	6.45±1.19	3.05±2.58	2.60±2.82
Algometry (kg/cm^2)			
Experiment	3.85±2.62	6.00±3.61	6.85±3.68
Sham	4.93±2.53	5.93±2.87	6.29±3.20
Mean trapezius elevation strength			
Experiment	62.25±9.24	65.25±10.70	134.50±79.70
Sham	130±99.73	134.29±105.23	137.86±100.47

As presented in Table 5, statistically significant results were reported in the experimental group for the VAS and algometry when comparing the baseline to testing immediately after application ($p<.05$), and again after one month ($p<.05$). Statistical improvement was also identified in the sham group from baseline testing to immediately after application ($p<.05$); however, improvement plateaued between post-application and follow-up testing for both VAS and algometry. Information obtained from this research not only supports that Kinesio® Tex tape provides a reduction in pain, but it may also provide results regardless of tension applied. Additionally, these results persisted for one month in the experimental group, indicating that there may be lasting affects at a higher tension.

Data obtained from this study also indicate an improvement in trapezius muscle strength with the application of Kinesio® Tex tape. In the experimental group, strength significantly improved from the pre- to the post-application test ($p<.05$) and improved at the time of the follow-up ($p<.05$). When comparing these results to those of the sham test, for which no significant improvement was identified, it can be inferred that Kinesio® Tex tension may improve muscular strength both immediately and after one month. While researchers present significant data supporting the use of Kinesio® Tex tape, there are several limitations that may have affected these results. As previously mentioned, tape was applied at 100% tension, contradicting parameters identified by the Kinesio® Taping method. Similar research should be completed applying the suggested parameters and compared to the current study to support or refute the guidelines. Other limitations that may have affected the outcome of this study include a small number of participants, participants completing a supplemental exercise program, researchers were not blind to group allocation of participants, and no control group for comparison. While researchers conclude there was an improvement in active upper trapezius trigger points associated with neck and/or upper back pain with Kinesio® Tex tape, additional research should be completed to more accurately define parameters that can provide maximal pain relief.

Research has also been completed to identify the effect of Kinesio® Tex tape on pain in subjects with whiplash following motor vehicle accidents. [83] Researchers evaluated 41 participants; 21 were randomly allocated to the experimental group, and 20 to the sham group (M=33±7 years; 20 Male, 21 Female). Though the previous study also used application to the cervical region, the present study utilized 15-25% tension through the tape following guidelines specified by the Kinesio® taping method. Kinesio® Tex application in the experimental group was applied using a vertical "Y" strip and a horizontal space correction strip. The "Y" strip was anchored at the superior vertebrae of the thoracic segment and was applied proximally to the superior vertebrae of the cervical segment. The space correction piece was applied horizontally to the midcervical region. Two "I" strips were applied to the cervical spine in the sham participants with no tension, one was placed vertically and one horizontally. Each person was evaluated initially to develop a baseline, again following application, and a third time 24 hours later. In addition to obtaining a pain measurement using the numerical pain rating scale (NPRS), cervical range of motion was taken in all three planes. Cervical range of motion was obtained through an average of three trials using a gravity inclinometer[84] placed on top of the participant's head. Results were compared using mixed-model ANOVAs between baseline testing and immediately following application, and again between baseline testing and 24-hours following application. Independent t-tests were used when comparing data between the control and experimental groups.

Table 6. Change in Scores for Neck Pain (VAS) and Cervical Range of Motion (Degrees).

Outcome/ Cervical Direction	Baseline	Immediate post-treatment	Change in scores (Baseline-immediate)	24-hour follow-up	Change in scores (Baseline- 24-hour follow up)
Pain (0-10)					
Experimental	4.3±0.9	3.3±0.9	-1.0(-1.2, -0.8)	3.2±1.0	-1.1(-1.5, -0.9)
Control	4.2±0.7	4.1±0.8	-0.1(-0.2, 0.0)	4.2±0.8	0.0(-0.1, 0.1)
Cervical flexion					
Experimental	55.8±5.7	60.7±5.6	4.9(3.9, 5.8)	60.6±6.1	4.8(3.2, 6.5)
Control	56.6±4.9	54.9±4.7	-1.7(-2.6, -0.7)	54.0±4.1	-2.6(-4.0, -1.1)
Cervical extension					
Experimental	46.7±8.3	54.9±10.9	8.1(6.2, 9.9)	54.9±8.1	8.1(6.2, 9.9)
Control	48.8±4.7	48.7±4.4	-0.1(-1.0, 1.0)	48.4±4.2	-0.4(-2.0, 1.2)
Cervical right lat. Flexion					
Experimental	42.3±5.1	47.2±5.6	4.9(3.6, 6.1)	47.1±5.3	4.8(3.4, 6.2)
Control	43.3±4.6	47.2±5.6	-0.6(-1.6, 1.0)	42.3±3.6	-1.0(-2.3, 0.0)
Cervical left lat. Flexion					
Experimental	41.8±3.7	44.5±5.4	2.7(1.0, 4.6)	44.1±5.3	2.3(0.5, 4.1)
Control	42.9±4.1	42.5±3.5	-0.4(-1.9, 1.2)	42.9±2.6	0.0(-1.9, 1.9)
Cervical right rotation					
Experimental	56.1±7.1	61.1±8.4	5.0(3.5,6.3)	60.9±8.0	4.8(3.2, 6.5)
Control	55.2±5.3	54.6±3.4	-0.6(-1.9, 1.0)	53.9±4.2	-1.3(-2.8, 0.0)
Cervical left rotation					
Experimental	55.7±6.9	59.9±7.6	4.2(2.8, 5.6)	58.7±8.8	3.0(1.7, 4.5)
Control	55.5±5.9	54.5±6.4	-1.0(-2.0, 0.0)	54.4±5.5	-1.1(-2.2, 0.0)

Statistically significant results were reported when comparing baseline testing to post-application testing ($p<.001$), and baseline testing to the 24-hour follow-up ($p<.001$) for both the NPRS and cervical ROM. The independent t-tests also indicated improvement between the two groups was statistically significant ($p<.001$). Together, these results indicate that not only does Kinesio® Tex tape improve cervical pain, but tension and correct application location play a critical role in its effectiveness. Additionally, as indicated above in Table 6, statistically significant results were indicated for the within-group and between-group comparisons for cervical range of motion testing ($p<.001$). Improvement was consistent in all three planes from baseline to immediate post-testing; results were maintained through 24 hours. When comparing the two groups, statistically significant results were also observed in all planes, further indicating tension and location are key factors. Analysis of these results indicate Kinesio® Tex tape may reduce cervical pain and provide enough relief to increase pain-free range of motion, or mechanically effect subcutaneous tissue. Unfortunately, significance of both tests is limited to statistical effect. When analyzing NPRS scores, improvement of two points on the scale indicates clinically relevant results.[85] This study exhibited mean reduction of one point when comparing baseline to immediate post-testing and 1.1 when comparing baseline to 24-hour follow-up, indicating no clinical significance. In addition, results obtained in cervical range of motion testing also did not reach clinical significance as measurements did not indicate a clinically detectable change.[86] While these results may not demonstrate statistical clinical value, they do represent a relationship between Kinesio® Tex tape, pain, and range of motion. To further strengthen these conclusions, supplementary research should be completed with more participants to identify long-term results with the same application and methods.

Knee pain is a common complaint in the physically active population. Several studies have been completed to identify the effect of taping knee pain particularly related to patellofemoral tracking pathologies.[87-90] Kinematics of the hip may subsequently affect pain and mechanical function of the knee. A cross-sectional study used Kinesio® Tex tape to identify the relationship of femoral rotation to pain and muscle activation in patients with patellofemoral pain.[89] Sixteen females with patellofemoral knee pain (M=25.7±6.1 years), and eight females with no history of knee pain (M=28.6±5.7) were recruited for the study. Participants from both groups were taken through three consecutive tests in a random order with 30 minutes rest between each test. Three trials were completed: no tape, a sham taping application, and a femoral rotational taping application using Kinesio® Tex tape. During each trial, participants completed three single-leg squats (SLS) to 45°; this was completed three times for each trial with 30 seconds rest between each set. Kinematic measurements were taken through sensors applied at the sacrum, lateral thigh, lateral glutes, and the patella; then, three-dimensional coordinates were calculated through each SLS. Measurements were also taken using surface EMG with electrodes placed on the gluteus maximus, gluteus medius, and rectus femoris. Additionally, participants were asked to rate their pain during each trial on a 10-point VAS scale. For the experimental taping trial, both groups were taped while standing with the femur in maximal external rotation. An “I” strip of Kinesio® Tex tape was applied with 20% tension from the inferior-medial aspect of the thigh superiorly and posteriorly across the buttock and anchored at the PSIS. The sham application tape was applied similarly, however, participants stood in a neutral position and tape was applied without tension. The VAS scale was analyzed using a one-way ANOVA, while data from the kinematic and EMG testing were compared using two-way mixed ANOVAs. The most relevant statistically significant result identified by researchers was improvement in VAS scores reported by the PFPS group. When compared to the no tape trial, statistically significant results were seen in both the sham trial, and the Kinesio® Tex experimental trial as depicted below in Table 7.

Table 7. VAS Scores Reported by the PFPS Group.

No Tape	Sham	Experimental
3.78±1.65	2.40±1.78	2.36±1.67

Researchers also reported data indicating females with PFPS had greater hip adduction and lesser rectus femoris muscle activation then their healthy counterparts. These results support the hypothesis that Kinesio® Tex tape provides pain relief. Similar to the previously discussed study,[83] these results lack clinical significance of greater than two points on the VAS scale.[86] Several limitations exist including the utilization of an inhibitory taping application applied from insertion to origin with the expectation of greater muscle activation. To activate musculature in the hip to stabilize the knee, a concentric muscle contraction should be initiated. Additional research should be completed utilizing a facilitatory tape application with the same methods to compare the two applications. Furthermore, additional research should include a larger number of participants and a wider population range so results can be applied to a general population. Should a similar study be completed, EMG data should be collected from more muscle groups to better understand the quality of muscle contraction during a SLS. Finally, further research should be completed to identify prolonged effects of Kinesio® Tex tape as a treatment for pain. While this research does support the use of Kinesio® Tex tape for acute pain reduction, additional research must be completed to further support this notion.

2.4. Tendons

Though Kinesio® Tex tape can be applied to tendons, very little evidence is available to support or refute application to tendinopathies. The Kinesio® taping method indicates tension of 50% be applied to tendons to provide a supportive result; 50% or greater tension no longer provides a recoil mechanism, removing facilitatory effects. These supportive applications are designed to prevent injury and re-injury to tendons. Research is limited to the lower extremity, particularly the Achilles and peroneal tendons.

One notable study was conducted to identify the effect of kinesiology tape on function, pain and nerve excitability in both healthy participants and participants with Achilles tendinopathy.[91] Twenty-six healthy participants (M=27.6±5.4 years; m=4, 22 f=22) and 29 participants with Achilles tendinopathy (M=44.5±10.7 years; m=17, 12 f=12) were recruited for this study. Four physical therapists, not blinded to the study, applied Vivomed® kinesiology tape despite citing the Kinesio Taping Method® application parameters. Application required the participants to lay prone with the ankle in active dorsiflexion. Tape was anchored at the base of the calcaneus and applied with 50-75% tension proximally over the Achilles tendon. Tension was then decreased to 15-25% over the musculotendinous junction, and the proximal anchor was applied without tension. Each participant in the Achilles tendinopathy group completed a Victorian Institute of Sports Achilles Tendon Scale (VISA-A) to identify their severity of functional deficit.[92] A low score indicates a low degree of functionality, while a high score indicates a high degree of functionality. Researchers reported a wide range of disability in VISA-A scores with participants scoring 21 to 94 on the scale (M=60±18 points). Functional performance was then tested in all participants using the single hop test.[93] In randomized order, each participant completed the test both with and without tape. Participants were instructed to complete a single leg hop as far as possible while still being able to land and hold the position for two seconds. Three attempts were given with each condition, tape and no tape, and the furthest attempt was recorded. Self-reported measures were also obtained using a visual analog scale (VAS); participants reported a score before tape was applied, following application, and after removal of the tape. Finally, H-Reflex in the gastrocnemius and the soleus was measured using EMG through stimulation of the tibial nerve. Results of the hop test and H-reflex amplitude were analyzed using a two-way repeated ANOVA, while VAS scores were compared using a one-way repeated measures ANOVA.

The hop test outcomes indicated that Vivomed® kinesiology tape did not increase functional movement in participants with Achilles tendinopathy. While the healthy participants hopped significantly further than the participants with Achilles tendinopathy (p<.0005), no significant data were obtained when comparing tape to no tape conditions in either group. Results of the VAS scores were also not significant (p=.74) when comparing the baseline to scores after the hop test and after the removal of tape. Finally, data obtained during the EMG testing indicated no statistically significant change in amplitude in the Achilles tendinopathy group when comparing the baseline to results after the hop test and after removal of the tape. However, significant increase in amplitude was found in healthy participants upon removal of tape in the soleus and gastrocnemius muscles (both, p=.001).

Although results of this study do not support the use of kinesiology tape for tendons, there are several limitations that compromise the methodology and conclusions. As a result of this study, researchers concluded that kinesiology tape does not affect participants with Achilles tendinopathy; however, they utilized Vivomed® kinesiology tape while citing the Kinesio® tape method of application. Results of this research cannot be generalized to all brands of kinesiology tape. Additionally, the tape method applied was designed to provide support to the Achilles tendon, not increase muscle facilitation.[7] According to the Kinesio® method, when tape is applied at a tension greater than 50%, it no longer provides a recoil effect; therefore, the lack of increase in H-reflex amplitude should not be considered a negative finding. This research included both male and female participants; however, female participants grossly outnumbered male participants in the healthy group. This is a limitation as it reduces validity of between-group comparisons due to physiological differences between genders. Finally, only immediate effects were researched; therefore, these results cannot be generalized to long-term application of kinesiology tape. While these researchers claim that kinesiology tape provides minimal support to the Achilles tendon, the many limitations indicate further research is required to draw an accurate conclusion.

A case study has also been completed to identify the effects of a supportive kinesiology tape application to the Achilles tendon in a 22-year-old badminton player.[94] The individual participating in the study had been injured six months prior to the study. Researchers conducted this study over the course of five weeks. Kinesio® Tex tape was applied six times per week for the duration of approximately ten hours. The tape application was completed by a Kinesio® Taping Certified Practitioner with the patient prone and maintaining active dorsiflexion. At 30-40% tension, a Kinesio® Tex tape “I” strip was applied from the posterior calcaneus proximally to the musculotendinous junction. With the same tension, a “Y” strip was anchored at the calcaneus and applied proximally to the medial and lateral condyles of the femur. Finally, with the ankle in a neutral position, two “I” strips were applied; one anchored at the medial malleolus, applied beneath the calcaneus and to the lateral malleolus, and the other applied similarly from lateral to medial. The goal of these final two strips was to decrease the space in the ankle mortise. The individual participated in five tests each week over the five-week period. Active dorsiflexion and plantar flexion were tested using a goniometer. The individual also completed a 100-point VISA-A questionnaire to evaluate pain intensity and functionality. A second, ten-point questionnaire was used to identify levels of load-induced pain. Pressure-pain threshold was tested using an algometer with pressure increasing at 0.1 kg/s until the patient reported feeling pain. Finally, tenderness was tested, also using a pressure algometer. The individual was asked to report his level of pain on a scale of zero to ten as the algometer applied a pressure of three kilograms. Findings of these tests at each weekly increment are displayed below in Table 8. Ultrasonography was also used to identify tendon thickness over the pre-insertional area where the greatest amount of pain was located.

Table 8. Results of Weekly Assessments.

Assessment	Initial	Week 1	Week 2	Week 3	Week 4	Final
Active dorsiflexion (°)	15	20	20	20	20	20
Active plantar flexion (°)	20	40	40	45	45	45
VISA-A (0-100 points)	64	72	86	86	86	95
Load-induced pain (0-10 points)	6	2	0	0	0	0
Pressure-pain threshold (kg)	0.8	3.5	8	9	10	10
Tenderness at 3 kg (0-10 points)	7	3	2	0	0	0

Unfortunately, because the ultrasonography was only completed on the first and last days, there is no way to identify the progress throughout the five weeks. When the original measurements were taken, the injured Achilles tendon measured 0.42 cm, compared to the uninjured side that measured 0.38 cm. On the final day, researchers report that the injured tendon was reduced to 0.37 cm, indicating objective results of the Kinesio® Tex tape applications. Each of the other tests completed also resulted in improvement demonstrated on a weekly basis. Active plantar flexion and dorsiflexion range of motion improved immediately, resulting in ranges considered to be normal (45° and 20°, respectively).[95] The VISA-A questionnaire also showed improvement, increasing from 64 points to 95 points.[92] Load-induced pain decreased from six to zero points on the pain rating scale indicating the patient no longer felt pain while load bearing. Pressure-pain threshold also increased dramatically from an initial weight of 0.8 kg to a final weight 10 kg. Tenderness with three kg of pressure rated on the zero to ten scale indicated improvement from the initial seven points to an eventual zero. The individual also reported he was able to participate in badminton and soccer without pain. Results of this case study indicate Kinesio® Tex tape may have positive results when applied to tendons of amateur athletes. While this study supports the use of Kinesio® Tex tape to the Achilles tendon, it is difficult to generalize these results as there was only one participant. One primary limitation exists within this research, including the short application duration. Kinesio® Tex tape can be worn up to three days, so it is unusual that researchers chose to re-apply six days each week. It is possible that if each tape application had been left on for an extended period of time, results may have been different. Additional research should be completed comparing the results of short-term and long-term Kinesio® Tape applications over a similar length of time. Additionally, it is also important to note that researchers reported applying tape at 30-40% tension. When applied from insertion to origin these parameters produce inhibitory results. Although this case study presented improvement with this application, further research should be completed under the recommended parameters. While this research cannot be generalized beyond this individual, these results support the continued research of Kinesio® Tex Tape to tendons.

While limited research is available examining the relationship of kinesiology tape to the Achilles tendon, fewer studies examine supportive application to the peroneal tendon. Researchers studying effects of kinesiology tape on peroneal tendons often complete applications with less than 50% tension, providing a facilitatory effect designed to enhance proprioception.[74,96-98] To provide support to tendons, Kinesio® Tex tape should be applied at greater than 50%, diminishing the recoil effect of the tape. One research study completed on healthy soccer players utilized an application of 50% tension to the peroneal tendon of the dominant leg.[99] Twelve healthy males (M=21.6±0.7 years) were studied over the course of three weeks prior to the competitive season. Two exercise protocols were completed under three separate taping conditions. Participants completed each exercise protocol with no tape, a zinc oxide tape application, and a RockTape® application. The zinc oxide tape application consisted of three stirrups applied from medial to lateral malleoli and an anchor applied above the malleoli; designed to provide support to the lateral ligaments of the ankle. The RockTape® application was applied with Kinesio® Tex taping parameters anchored at the origin of the peroneal tendons and applied at 50%; however, the patient was incorrectly positioned in ankle dorsiflexion and eversion. Participants completed a soccer-simulated protocol and a local fatigue protocol under each taping condition. The soccer-simulated protocol consisted of 45 minutes of running in an irregular pattern designed to imitate the first half of a soccer game. The local protocol included isokinetic ankle inversion and eversion exercises. The participants completed three sets of 30 repetitions at a rate of 60°/s with ten seconds rest between each set. Balance was tested prior to and following each exercise protocol using the Biodex Stability System (BSS). A single-leg balance test was completed on the dominant leg at a level two setting, designed to be challenging. An overall Stability Index (OSI), anterior-poster (AP) and medial lateral (ML) directional indexes were developed for each test. Trials were compared using a two-factor linear model with repeated measures.

When comparing the baseline measurement of the no tape trial (1.75±0.35) to the zinc oxide (1.39±0.31, p=0.13) and RockTape® (1.30±0.34, p=0.08) trials, no significant results were identified (Figure 2). However, following both the soccer-simulated and local protocols, the RockTape® and zinc oxide tape stability indexes were lower than that of the control. As presented in figure 2, improvement was seen in the OSI during the soccer-simulated protocol with the no tape condition (2.93±0.76) and the zinc oxide tape condition; meanwhile the RockTape® maintained an OSI similar to baseline. These results also persisted through the post-peroneal fatigue protocol where instability during the no tape condition (2.93±0.76, p=.01) and the zinc oxide tape condition (2.14±0.69, p=.05) increased significantly while the RockTape® condition did not. Furthermore, the ML index during the peroneal fatigue test with RockTape® indicated stability did not decrease unlike the ML index for the no tape condition (p=.02) and the zinc oxide condition (p=.05) (Figure 4).

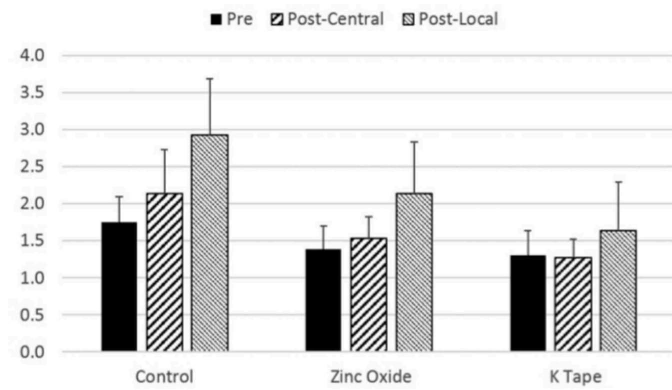

Figure 2. The influence of tape condition on the fatigue response in overall stability.[99]

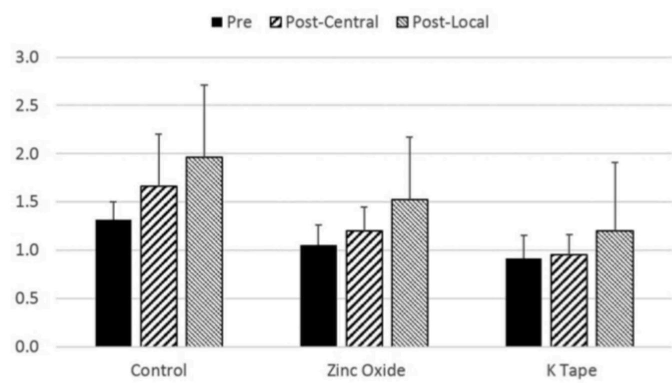

Figure 3. The influence of tape and trial type on the anterio-posterior index.[99]

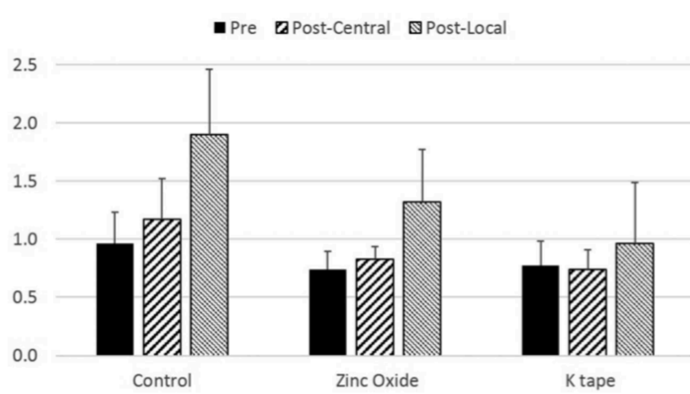

Figure 4. The influence of tape and trial type on the medio-lateral balance index.[99]

Several conclusions regarding the effectiveness of RockTape® on tendons can be drawn from these results. As expected, fatiguing the tendon proved to be detrimental to ankle stability regardless of the condition. However, supporting the tendon with either the zinc oxide or the

RockTape® applications decreased the impact of fatigue on stability during both conditions, indicating a positive result due to lateral support. This was particularly evident during the ML index where there was no significant change reported from the control to the soccer simulated and local fatigue protocols under the RockTape® condition. These results indicate that kinesiology tape has supportive benefits when applied to the peroneal tendons. Similar to the study on the Achilles tendon, the tape application was completed utilizing Kinesio® Taping conditions with an alternate tape product.[91] Conclusions cannot be developed regarding Kinesio® Tex tape, and the Kinesio® taping method while applying RockTape®. Additional research testing the theory of supportive Kinesio® Tape applications should be completed with Kinesio® Tex tape under similar parameters. This research was also compromised by several additional limitations. Sample size for this study was small and limited to only healthy individuals. Because of this testing population, it is difficult to generalize results to fatigue in females or injured populations. Though findings of this research support the use of kinesiology tape to tendons, additional research should be completed utilizing Kinesio® Tex tape, additional fatigue protocols, and alternative populations.

Research regarding the use of kinesiology tape to tendons has varying results. Of the few articles available, few oblige by the Kinesio® method of application while using Kinesio® Tex tape. Results of research using different methods or products cannot be generalized to all brands. Considering the limitations of the previously mentioned studies, additional research must be completed to draw accurate conclusions with respect to the application of supportive Kinesio® Tex tape applications to tendons, and particularly tendinopathies.

2.5. Proprioception

Proprioception is a critical component of injury prevention and rehabilitation. Touch, joint movement, and joint position compose the sensory modality that allow an individual to detect subconsciously the position and movements of the body.[100,101] Mechanoreceptors located in the skin, joints and muscles send messages to the brain and spinal cord. Cutaneous, articular, and muscular mechanoreceptors travel at a speed of approximately 70-100 meters per second (m/s); much faster than nociceptors, which travel at approximately one m/s. Because mechanoreceptors deliver information regarding position and movement faster than nociceptors deliver information regarding pain, having a strong sense of proprioception may prevent injury.[102] If injury does occur, mechanoreceptors within the tissue are compromised, increasing the possibility of further detriment.[100,103] In addition to local proprioceptive structures being affected by injury, researchers have proven that activation sequences in the contiguous joint may also be compromised.[104] Finding ways to improve proprioception in fatigued and injured individuals is imperative to injury prevention. The Kinesio® Method claims to positively impact the sensorimotor system due to its cutaneous effects, tension and recoil effecting subcutaneous tissue.[103] Researchers have included multiple parameters to test the claim that Kinesio® Tex tape can aid in proprioception.

Several studies have been completed to identify the effect of Kinesio® Tex tape on healthy tissue. Heightened response of mechanoreceptors as a result of Kinesio® Tex application indicates its use as a preventative modality. While Kinesio® Tex tape is often referenced as a tool for rehabilitation, most research on proprioceptive benefits in the knee have been completed as preventative measures in healthy individuals.[72,101,105-109] One study in particular has been designed to determine the effect of kinesiology tape on healthy participants over the course of 24 hours.[105] Thirty participants (M=21.3±1.4, m=15, f=15) were randomly divided into control (n=10, m=5, f=5) and experimental groups (n=20, m=10, f=10). Joint position sense (JPS) and threshold to detect passive movement (TTDPM) were tested in both groups prior to and following tape application. JPS is the ability to determine the angle and location of a joint, while TTDPM is the ability to detect passive movement of the joint, measured in degrees; both measurements were conducted without visual input. Data were collected for both tests using the Biodex isokinetic dynamometer before, after, and 24 hours following tape application. During the JPS test, participants were seated in the dynamometer at 110° of hip flexion. The test was completed with the subject's eyes closed, noise cancelling headphones on, and an air cushion applied to the thigh at 40 mmHg to limit any visual, auditory, or cutaneous sensory input. From the initial position of 90° of knee flexion, the dynamometer passively moved the participant's leg to 30° or 60° of flexion at a rate of ten degrees per second. The position was maintained for five seconds and passively returned to the starting position. At this time, the participant was instructed to actively reproduce the angle and press a button to stop the dynamometer arm when they felt they had reached initial angle. This test was completed three times and the absolute error was identified by determining the difference between the target angle and calculating the mean deviation of the three trials. The TTDPM test was completed similarly to the JPS test; however, the knee was initially held in either 30° or 60° of flexion. Movement of the dynamometer was randomly started by the researcher in the 30 seconds following instruction. The knee was then passively extended at a rate of 0.25°/s, and participants were instructed to press a button when they detected movement at the joint. This test was also completed three times and an average score (°) was identified. Despite referencing the Kinesio® Taping Method, CureTape® was applied to the participants in the experimental group. Lying prone with the hip in full extension and the knee flexed, tape was anchored at the anterior inferior iliac spine (AIIS) and applied at 50-75% tension distally to the proximal patella. Tape was then split and applied at no tension to either border of the patella and anchored at the anterior tibial tuberosity. Participants were instructed to leave the tape on until testing was completed the following day. The participants in the control group did not receive a tape application. The Mann Whitney U-test was used to analyze the difference between groups, while the Friedman test was used to analyze the relationship between groups.

Though there were no significant differences identified during the JPS testing, TTDPM testing did reveal improvement with the application of kinesiology tape. As presented below in Table 9, at both 30° ($p<0.005$) and 60° ($p<0.017$) knee flexion, TTDPM decreased in the experimental group both immediately after application and 24 hours following baseline. This improvement was not noted in the control group, thus indicating that CureTape® had some impact on cutaneous and subcutaneous mechanoreceptors. While this research indicates kinesiology tape may mediate TTDPM at the knee, several limitations challenge the generalizability of these outcomes. First, researchers reference the Kinesio® Taping Method parameters, but apply CureTape®. Because tapes have different qualities, it is impossible to generalize both positive and negative results of the study to Kinesio® Tex tape and other kinesiology tapes. Researchers also solely studied healthy participants, making it difficult to generalize the response to participants in an injured or fatigued state. Finally, researchers did not apply a tape application as a placebo in the control group. Because no placebo was applied, the results of this study indicate that a possible learning process took place. As a result, the control group improved with each test despite having no intervention. However, it is important to note these improvements were not statistically significant. Though these limitations compromise the integrity of the results, this study provides a basis for further research with corrected parameters.

Table 9. Comparison of TTDPM Before, Immediately After, and 24 Hours Following Intervention. Mean Absolute Values (Degrees °), (Interquartile Values).

TTDPM	Groups	Before tape	Immediately following	24 hours following	Friedman test
30° knee flexion	Experimental	2.33 (1.33)	1.00 (0.67)	1.33 (1.67)	**0.005**
	Control	1.83 (1.37)	1.33 (1.08)	1.17 (1.00)	0.060
Mann-Whitney U test		0.243	0.307	0.894	
60° knee flexion	Experimental	2.00 (1.50)	1.33 (1.42)	1.00 (0.87)	**0.017**
	Control	1.83 (1.92)	2.33 (2.54)	1.17 (0.92)	0.131
Mann-Whitney U test		0.913	0.078	0.960	

As previously stated, fatigue significantly decreases proprioceptive ability.[110,111] In addition to a reduction in performance, as muscles become fatigued the mechanoreceptors controlling balance and proprioception become compromised, thereby possibly resulting in injury or re-injury. Because a deficit in balance and proprioception due to muscle fatigue at the knee is related to increased risk of subsequent knee injuries, developing techniques to counteract this deficiency may be impactful.[112] One of the proposed benefits of Kinesio® Tex tape is its enhancement of proprioception and balance.[7] Two studies in particular have been completed to evaluate the effects of kinesiology tape on proprioception at the knee in healthy, fatigued participants.[72,106] Both protocols utilize the same application with Nasara Original kinesiology tape, however, one study evaluated 12 female participants (M=23.6±2.0) and one evaluated 12 male participants (M=23.3±2.6). During the tape application participants sat with the knee flexed at 90°. The first "I strip" was applied ten centimeters distal to the greater trochanter and applied distally with 75% tension inferiorly over the vastus lateralis to the lateral border of the patella. The tape was then applied with full tension lateral to medial around the distal patella. The second strip was applied similarly; anchored at the middle third of the medial thigh and applied distally to the medial border of the patella where tension was increased to 100% as it was applied medial to lateral across the patella. A third “I-strip” was applied over the distal patella at full tension.

Though taping applications were identical, the evaluation process differed between the two studies. The first study utilized a camera recording of an open- chain, active-angle reproduction test at the knee.[72] Patients were seated, blindfolded, and markers were applied 10 cm distal to the greater trochanter of the femur, at the lateral femoral condyle and the lateral malleolus. The evaluator passively moved the patent’s knee into 20-70° of knee flexion and held the position for 5 seconds. The leg was then returned to the original position, and the participant was directed to reproduce the angle and maintain the position for five seconds; the degree of deviation was then calculated. Each participant completed three practice attempts and six experimental attempts; a mean score was developed from the results. This testing was conducted prior to and following the fatigue process, which consisted of 30 minutes of uphill walking at 20% incline at a speed calculated based on the participant’s leg length. Testing was randomized and the experimental and control were completed on two separate occasions with one week separating the encounters.

The second study utilized the Biodex balance platform to assess balance and proprioception before and after fatigue.[106] At a moderate stability level of four, participants were instructed to stand on their dominant leg in the middle of the platform with their eyes open, hands on their hips, and other knee flexed at 90°. During the 20-second test, participants were to keep the platform as steady as possible. One practice test was given followed by three test trials with rest of 30 seconds in between. In addition to a calculated overall stability index (OSI), a $t_{zone\text{-}A}$ average was calculated; the balance platform software calculates time spent in each of the four “T” zones (zone A=0°-5°, zone B=6°-10°, zone C=11°-15°, zone D=16°-20°). Participants who spent a large percentage of time in $t_{zone\text{-}A}$ were identified to have superior balance than those who averaged greater than five degrees of deviation. During the fatigue portion of this experiment, participants walked on a treadmill at a 20% decline at a speed calculated based on individual leg length. For both experiments, similarity to the normal distribution was evaluated using the Shapiro-Wilks test. The first experiment used a paired t-test to compare angle deviations between tests, and the second test used two-way repeated measures analysis of variance to compare the tape factors, the condition, the OSI and $t_{zone\text{-}A}$ results.

Table 10. Comparison Between Not Taped and Kinesiology Tape on Knee Angle Deviation Prior to and Following Fatigue (°).

	Not taped	Kinesiology Tape	p
Whole group (n=12)			
Deviation prior (°)	4.4±1.4	4.2±1.6	.749
Deviation following (°)	6.1±1.7	5.2±1.2	.221
Change (°)	1.7±1.7	1.0±2.0	.414
Subgroup >6.1° (Poor)			
Deviation prior (°)	5.1±1.4	4.3±1.0	.284
Deviation following (°)	7.4±0.9	4.6±1.0	**.002**
Change (°)	2.3±1.9	0.3±1.7	.102
Subgroup <6.0° (Good)			
Deviation prior (°)	3.4±0.4	3.9±2.2	.685
Deviation following (°)	4.4±0.8	5.9±1.1	.103
Change (°)	1.0±1.2	2.0±2.0	.518

Table 11. OSI and Time Spent in $t_{zone\text{-}A}$ by Condition and Time.

Condition	Time	Mean±SD	95% CI	Min	Max
OSI					
Without Tape	Pre-exercise	2.5±0.6	2.1, 2.9	1.5	3.7
	Post-exercise	3±0.9	2.4, 3.5	2	4.5
		0.5±0.5	0.2, 0.8	-0.4	1.4
With Tape	Pre-exercise	2.5±0.7	2.1, 3.0	1.9	4.2
	Post-exercise	2.6±0.5	2.3, 3.0	2.1	3.7
		0.1±0.4	-0.2, 0.3	-0.6	0.5
$t_{zone\text{-}A}$					
Without Tape	Pre-exercise	97.9±4.4	94.4, 100.8	85.5	100
	Post-exercise	94.8±7.4	89.8, 99.7	78.5	100
		3.1±4.3	0.3, 5.8	0	11.8
With Tape	Pre-exercise	97.8±3.9	95.2, 100.4	87.3	100
	Post-exercise	98.2±3.4	95.9±100.4	88	100
		0.3±2.6	-1.9, 1.3	-7.6	3.5

Results of the first study revealed no significant difference when comparing the control and experimental trials both before (p=.749) and after fatigue (p=.221).[72] Because no statistically significant result was identified, researchers grouped the participants based on deviation scores. Seven of the 12 participants averaged a deviation greater than 6.1°, classifying them as having poor proprioception. When analyzing these results separately, statistically significant improvement was seen with application of kinesiology tape after fatigue (p=.002), while the group with good proprioceptive ability (less than 6.1°) did not demonstrate the same improvement (p=.103). These results indicate that kinesiology tape has a positive effect, particularly in participants who have a proprioceptive deficit. Similar results were identified in the second experiment (Table 11).[106] Unfortunately, like the previously discussed study, overall statistical significance was not observed when comparing the tape to no tape conditions (p=.198). However, notable change was detected when comparing scores without tape prior to fatigue and scores with kinesiology tape following fatigue (Figure 5). Participants who initially had a high OSI score, indicating poor proprioceptive ability, benefited most from the application of kinesiology tape, with their scores only changing slightly. Greater deterioration in balance was evident in those with a lower initial score, suggesting the tape has a greater affect on those with a proprioceptive deficit. Together, results of these studies support the use of kinesiology tape in fatigued participants demonstrating a weakened balance and proprioceptive system, and also indicates that further research must be completed in this area.

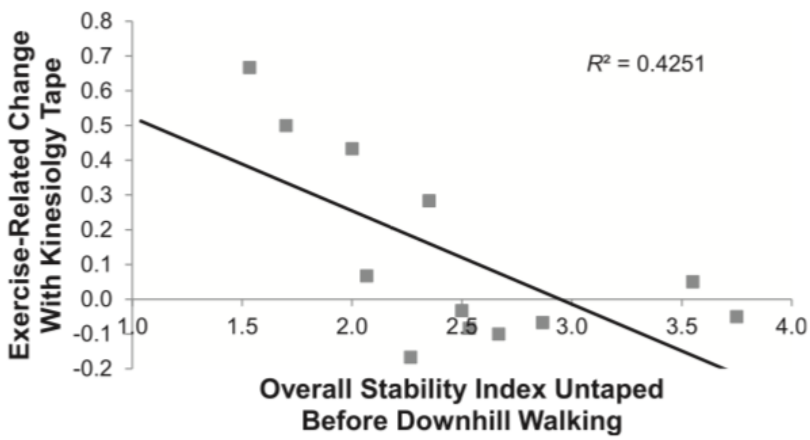

Figure 5. Exercise related change in the OSI with the use of kinesiology tape.

Though both studies present some conclusive results, several limitations challenge the extent to which these results may apply. Similar outcomes were noted in both studies, demonstrating effects are not gender exclusive; however, only studying young, healthy participants limit the ability to further generalize these results. Albeit researching fatigue due to both concentric (uphill) and eccentric (downhill) exercise, it is difficult to further apply these results to participants completing longer and more intense exercise. The first study also utilizes an open-chain test, which while accurate, is not a functional test. The second study utilized the Biodex balance system, which is considered more functional, however, it is also important to note that mechanoreceptors at the hip and ankle also influence balance and proprioception. Further research should identify results of additional tape applications at related articulations. Finally, both studies reference the Kinesio® Taping method despite applying Nasara® Original tape. As previously stated, tapes cannot be interchanged. This research warrants additional study with Kinesio® Tex tape to enhance the validity of these results.

Although several researchers have analyzed the effects of fatigue on proprioception at the knee, limited research is available to understand the relationship between knee proprioception, kinesiology tape, and injury. The available research is primarily limited to participants post anterior cruciate ligament rupture,[113,114] in addition to studies evaluating geriatric patients suffering from osteoarthritis.[115] One of few studies completed analyzing a large, young population identified the effects of Kinesio® Tex tape on proprioception in participants with patellofemoral syndrome (PFPS).[116] Ninety participants and 112 knees were included in this study. Participants were randomly assigned to two groups: 44 to the Kinesio® Tex group (M=31.6±6.9, m=19, f=25) and 40 to the placebo group (M=30.9±7.2, m=16, f=24). The tape application was applied by a Certified Kinesio® Tape Practitioner with the goal to facilitate the vastus medialis oblique (VMO) and to correct patellar tracking. With the participant in a seated position and the knee at 90°, a "Y-strip" was anchored over the middle third of the rectus femoris and applied distally to the superior patella where the tails were applied around the patella with no tension. A second "I-strip" was applied at the distal patella at "medium" tension. The placebo application consisted of two Kinesio® Tex "I-strips" applied horizontally seven cm both proximal and distal to the patella. A variety of tests were performed to determine level of pain, degree of kinesiophobia, quadriceps strength, and proprioception at the effected knee(s). Two separate methods were used to evaluate pain. A 10-point VAS scale was completed to evaluate the participant's level of pain while walking, ascending and descending stairs. Also, to evaluate pain, a Kujala pain scale (KPS) was administered. The KPA is designed specifically for PFPS to evaluate the severity of symptoms and physical limitations. To quantify kinesiophobia, the fear of movement and re-injury, the Tampa Scale (TSK) was completed. The TSK consists of 17 statements participants are required to answer via a four-point scale ranging from agree to disagree. The Cybex Isokinetic Dynamometer was used to evaluate participant's quadriceps strength. Participants were seated with their hips and knees at 90° of flexion, and the dynamometer was aligned parallel to the lateral femoral condyle. After trial repetitions for practice, three tests were completed at 60°/s and at 180°/s with 30 seconds rest between each set. With the same dynamometer, joint position sense was evaluated. For this test, participants were blindfolded, and a pneumatic boot was placed on the ankle and lower leg to reduce visual and cutaneous input. The Cybex dynamometer was set to the cutaneous passive motion setting, which flexes and extends the knee at a rate of five degrees per second. With 60° as the target angle, subjects were instructed to press a button when they felt their knee had reached that angle. This process was completed three times and the deviation was averaged. Normal distribution was measured using the Kolmogorov Smirnov test. From there, normally distributed data was evaluated using t-tests, and data that was not normally distributed was evaluated using the Mann-Whitney U-test.

Table 12. Measurements Before and After Kinesio® Tape Application.

	Kinesio® Tape Group		Placebo Kinesio® Tape Group	
	Before Tape M±SD	After Tape M±SD	Before Tape M±SD	After Tape M±SD
Proprioception (60°)	8.7±6.6	6.7±6.2	6.7±5.6	7.1±6.1
VAS	4.7±2.3	2.4±1.6	4.2±1.8	4.1±1.7
TSK	41.1±10.5	32.9±8.9	33.9±6.8	33.9±6.9
KPS	67.9±9.6	70.5±9.8	73.9±7.8	73.6±7.8

Table 13. Comparison of Changes Between Groups.

	Kinesio® Tape (M±SD)	Placebo Kinesio® Tape (M±SD)
Proprioception (60°)	-2.04±4.36	0.38±3.48
VAS	-2.23±1.98	0.98±1.63
TSK	-8.11±7.45	0.98±2.48
KPS	0.80±2.79	0.18±1.13

Improvement in the Kinesio® Tex tape group was identified in four of the five evaluations. As presented above in Table 12, statistically significant improvement in the proprioception test (p<.001), the VAS scale (p<.001), the TSK (p<.001), and the KPS (p=.002) was observed when comparing the baseline to testing following Kinesio® Tex tape application. In comparison, the placebo group did not see paralleled improvement in either the quadriceps strength testing, the proprioception test, the VAS scale (p=.547), the TSK (p=.779), or the KPS (p=.396) when compared to baseline. Although neither tape application revealed significant improvement in the quadriceps strength test, Kinesio® Tex tape was superior in all other evaluations (p<.001). Despite utilizing Kinesio® Tex tape and a Certified Kinesio® Tex Practitioner, several limitations exist. First, incomplete reporting regarding application tension make this study difficult to replicate. Second, researchers were not blinded, possibly leading to biased results. Finally, only short-term results were identified. Limitations aside, results of this study indicate that Kinesio® Tex tape is an affective intervention for patients who suffer from patellofemoral pain. While these results cannot be generalized to all knee pain and injuries, this study warrants additional research to identify the effects of Kinesio® Tex tape on other pathologies.

As proprioception plays such a critical role in injury prevention and rehabilitation, completing adequate research to identify effective treatment modalities is imperative. Although research supports the use of kinesiology tape as modality to enhance proprioception at the knee, data is limited to healthy individuals, those that have a deficit due to fatigue or those who suffer from patellofemoral pain. There is a clear gap in research specifically identifying the effect of Kinesio® Tex tape on proprioception at the knee in participants with patellar tendonitis. As a condition that is common in both the general population and athletes, research soley focused on this pathology would be beneficial. Additionally, despite understanding that hip strength has an influence on knee proprioception, research has not been completed to study the effect of Kinesio® Tex tape on this relationship. Further research should correct limitations of existing studies, expand current knowledge regarding proprioception and injury, and investigate the effects of Kinesio® Tex tape on the kinetic chain.

3. METHODOLOGY

The purpose of this study was to determine if Kinesio® Tex Tape had an effect on proprioception when applied to patients with patellar tendonitis. The Biodex Balance System was used to measure stability with and without taping applications. This chapter outlines the participants of this study, the setting in which it was completed, data collection, procedures, and data analysis. These research questions are the cornerstone of this study:

1. What are the with-in subject differences pre- and post- tape application as measured in the Visual Analog Scale (VAS), Tampa Scale for Kinesiophobia (TSK), and overall stability index of the Biodex Balance System?
2. What are the differences pre- and post- tape application between taping techniques as measured in the VAS, TSK, and overall stability index of the Biodex Balance System?

3.1. Participants

A purposive, convenience sample of 30 participants between the ages of 18 and 50 were recruited within the Fargo-Moorhead area. Email listserv, word-of-mouth, physical therapy and doctor referral were utilized to identify participants. Diagnosis of patellar tendonitis included patellar tendon pain for greater than 14 days, tenderness with palpation between the distal patella and the tibial tuberosity,[58] and a score of less than 80 out of 100 on the VISA-P questionnaire.[3] Exclusion criteria included knee surgery within the last 6 months, acute injury to the knee, and any other pain in the ankle, hips or core. Contraindications for Kinesio® Tex Tape including any allergy to adhesive, malignancies, cellulitis, skin infection, diabetes, or fragile skin are also cause for exclusion.[7] Twenty dollars of compensation will be awarded to each participant upon completion of the study. Informed written and verbal consent will be obtained from each participant prior to collection of information and completion of any part of the study.

3.2. Setting

This study will be completed in the Athletic Training and Exercise Science Laboratory in Benson Bunker Fieldhouse one the campus of North Dakota State University, Room 14, 1301 Centennial Blvd. Fargo, North Dakota, 58102 in the fall of 2019. Equipment required for this study (Biodex® Balance System, Kinesio® Tex Tape) is located at this site. In addition, this is a convenient location for participants in the Fargo-Moorhead area.

3.3. Equipment and Instrumentation

The Biodex® Balance System (BBS) will be used to measure proprioception at the knee. The machine consists of a balance platform that moves 20 degrees in all directions. It can be set to varying levels of resistance, making balancing either more or less difficult. The BBS calculates a score in both the frontal and sagittal planes, and then an overall stability index, which is a combination of the two. All three scores will be considered when analyzing data.

Kinesio® Tex tape will be utilized at the knee and hip as it is theorized to have both supportive and facilitative properties.[7] Classic Kinesio® Tape will be used for the hip application, while Performance Plus Kinesio® Tape will be used for the knee. Application recommendations provided by Kase et al.[7] include applying a supportive “sling” application at the patellar tendon. We chose to further analyze the kinetic chain effects by applying the gluteus medius application also defined by Dr. Kase.[7] All tape applications will be applied by a Certified Kinesio® Tape Practitioner (CKTP).

The VISA-P scale will be utilized as an aid in diagnosis to identify function, symptoms, and activity-related pain levels in people with patellar tendonitis.[59,61,63,92] The VISA-P scale consists of eight questions, six of which are specific to activities of daily living. The final two questions identify pain specific to athletic activity. Six of the eight questions are scored on a scale of one to ten. The seventh question can be given a score of zero, four, seven or ten out of ten. Finally, the eighth question identifies how long a participant can complete physical activity. The question is separated into three sections: one for those who can participate pain free, one for those who can participate despite pain, and one for those who cannot participate due to pain.

The Tampa Scale for Kinesiophobia (TSK) will also be utilized to collect additional self-reported data. The TSK is designed to evaluate fear-avoidance behavior which may result in altered biomechanics, and/or reduced physical activity possibly leading to prolong pain and disability.[117] The TSK consists of seventeen questions which are scored by the participant on a scale of one to four ranging from strongly disagree to strongly agree. The scoring of questions 4, 8,12 and 16 are reversed. Scores range from 17 to 64 with a higher score indicating greater fear of movement.[118]

3.4. Procedures

For this research study, participants were recruited through a North Dakota State University listserv, word-of-mouth, physical therapist and doctor referral in the Fargo-Moorhead area. The first 30 people that met the inclusion criteria were included in this study. The North Dakota State Institutional Review Board approved this research study prior to completion. Data was collected in the Athletic Training and Exercise Science Laboratory of Benston Bunker Fieldhouse during fall of 2019, and spring of 2020 on the NDSU campus. Participants were sent information about patellar tendonitis including signs and symptoms, expectations of the study, and the VISA-P to be completed. Participants had to score less than 80 out of 100 on the questionnaire in order to participate. In the instance that any participant reported neurological impairment (ie. Parkinson’s disease; nerve entrapment; MS; ALS; or paresthesia); history of medical conditions involving joints, muscles, bones, or connective tissue in the lower extremity (ie. Osteoarthritis, fibromyalgia, Lyme disease); or any allergy to adhesive or Kinesio® Tex Tape, they were unable to complete the study.

Participants who qualified for this study were randomly assigned to one of three Kinesio Tex tape application groups: knee only, hip only, and hip and knee. Each subject was assigned a number, and a random number generator was used to develop an order. The first ten numbers were assigned to the knee only group (K), the next ten were assigned to the hip only group (H), and finally, the last ten were assigned to the knee and hip group (KH). The knee only group received a supportive Kinesio® Tape application at the patellar tendon. The hip only group received a facilitative Kinesio® Tape application for the gluteus medius. Finally, the knee and hip group received both applications.

Participants reported to the facility twice throughout the duration of the study. During the first visit, the informed consent form was completed and instance of patellar tendonitis was confirmed through palpation. Pain with palpation located between the inferior pole of the patella and the tibial tuberosity was indicative of patellar tendonitis. Due to the requirements of the BBS, height measurements were collected with a standard standometer and weight with a manual scale. At this time, a baseline TSK and ten-point VAS scale in reference to the previous 72 hours were administered to identify current fear of movement and pain levels. During the first visit, participants were required to wear loose fitting shorts to provide the CKTP with the ability to tape the gluteus.

The Biodex® Balance System (BBS) was used to quantify proprioception without Kinesio® Tex Tape application, immediately following tape application, and 24-36 hours later. The BBS is a platform with the ability to move 20° in both anterior-posterior and medial-lateral axes. Over a 20-second time period, the software calculates time spent in the anterior-posterior

(AP) plane, the medial-lateral (ML) plane, and provides an overall stability index (OSI).[10] The AP, ML, and OSI tests are expressed as a sway index (mm/s). Platform stability may be altered by adjusting resistance; level one provides the least stability, while level eight is the most stable.

For this study, the BBS was set to level four in order to provide a challenging test.[106] Participants completed this study barefoot. Two 20-second practice tests with eyes open were allowed for each leg to familiarize participants with the procedure; one minute of rest was provided between the practice and the beginning of the test. Participants then completed two 20-second trials, the first with eyes open and the second with eyes closed. One minute of rest was then provided. The participant then completed two more 20-second tests, the first with eyes open and then with eyes closed. Participants will be instructed to maintain the platform as level as possible throughout the test, with no further coaching. Due to the challenging nature of the test, it was possible for participants to commit errors such as opening the eyes or touching the other foot or hands down. One evaluator monitored and documented number of errors per test while the other ensured the participant did not fall from the balance platform.

Following BBS testing, participants were taped as described according to their assigned group. The CKTP applied all applications according to methodology described by Dr. Kase. Participants in the K and H groups received the individual applications, while participants in the KH group received both.

Prior to the supportive patellar tendon application, the area was cleaned with an isopropyl alcohol preparation pad, excess hair on the skin was trimmed, and an adherent spray was applied. While waiting for the area to dry, the CKTP prepared one “I-strip” of four to five squares of Kinesio® Tex Performance Plus tape depending on the size of the participant’s knee. A tension chart was utilized in order to ensure consistency: the number of squares was dependent on the participants size, and the 75% tension distance was be calculated not including the anchors. Marks were then be placed on either side of the knee. The application was completed with the participant in a seated position. Paper backing was removed from the middle of the tape and anchored in the middle of the patellar tendon. The participant was instructed to actively flex at the knee as the middle third of the tape was applied at 75% tension. The ends were then anchored at no tension and friction was used to adhere the tape to the skin.

The facilitative gluteus medius tape application was applied with the participant in a side lying position with the affected side up. Similar to the previous application, the area was cleaned with an isopropyl preparation pad and excess hair will be trimmed. Adherent spray was applied to the taping area. The practitioner cut one Kinesio® Tex Classic Tape "Y-strip" equivalent to the distance from the ASIS to the greater trochanter of the femur. Referencing the tape tension table, the participant was measured and the tape tension area was marked as a way to provide consistency in tape tension. The paper backing was then removed from the full end of the tape and anchored with no tension at the iliac crest just lateral to the ASIS. The clinician instructed the participant to flex and adduct the hip; and the anterior tail was applied at 25% tension distally to the greater trochanter where the end was adhered without tension. The clinician then applied the second tail at 25% tension posteriorly across the muscle to the greater trochanter where the end was anchored without tension. Friction was used to adhere the tape application.

Following tape application, participants completed a second round of balance testing. Two 20-second trials were completed, the first with eyes open and the second eith eyes closed followed by one minute rest. A second trial eyes open, and a second trial eyes closed were then completed. After the second round of balance testing, participants were instructed to continue with activities of daily living until they returned for their second appointment.

The second appointment was scheduled 24-36 hours following the first. Upon arrival to the second appointment, the CKTP confirmed the tape application had remained intact. In the instance that the tape application was no longer correct, the participant's data was excluded from the study. At that time, participants completed a second ten-point VAS scale, the TSK, and BBS testing with the tape application. The participant was awarded 20 dollars compensation for completion of the study and was dismissed.

3.5. Data Analysis

In addition to descriptive statistics, analysis was conducted using repeated measures ANOVA, with each participant serving as his or her own control. The analysis will compare data from the three groups defined by the tape application technique. Four models will be computed for the six dependent measures: frontal, sagittal, and overall stability indices (from BBS) as well as the data from the VISA-P, TSK and VAS. Follow-up paired tests will utilize Tukey's honestly significant difference (HSD) methodology.

3.6. Conclusion

The purpose of this study was to determine the effect of Kinesio® Tex Tape on knee proprioception in participants with patellar tendonitis. The VISA-P scale and tenderness with palpation were used as diagnostic tools to confirm instance of patellar tendonitis and the TSK and VAS scales were used to identify degree of fear-avoidance and pain level in each participant. The BBS was used to quantify proprioception at the affected knee. A baseline measurement was taken prior to tape application, and measurements were taken immediately following application, and 24-36 hours following tape application. Kinesio® Tex tape was applied by a CKTP at either the knee, the hip, or both. Subjective data was also be collected via a 10-point VAS and TSK at baseline and 24-36 hours later. Results of this research have provided information regarding the application of Kinesio® Tex Tape on proprioception in participants with patellar tendonitis to identify treatment parameters and further patient outcomes.

4. MANUSCRIPT

4.1. Abstract

[Study Design] Randomized Control Trial

[Background] Patellar tendonitis is a common condition affecting both recreational and athletic populations.[1,2,14,46] Kinesio® Tape application to the site of injury and to treat through the Kinetic chain may be an effective treatment option for patients with patellar tendonitis.[48-55] Research to identify the effect of Kineiso® Tape on patellar tendonitis will allow clinicians to utilize evidence-based applications in their clinical practice.

[Objectives] To determine the effect Kinesio® Tape has on pain, kinesiophobia, and proprioception in participants with patellar tendonitis.

[Methods] This study consisted of 30 participants with patellar tendonitis as determined by history, palpation, and a score of <80 out of 100 on the Victorian Institute of Sport Questionnaire for patellar tendonitis. Participants were divided into three groups: n=10 receiving a supportive Kinesio® Tape application at the knee, n=10 receiving a facilitative Kinesio® Tape application at the hip, and n=10 receiving both applications. A Visual Analog Score, Tampa Scale for Kinesiophobia, and a proprioceptive score obtained through the Biodex Balance System (BBS) were obtained at baseline, immediately after application, and 24-36 hours following.

[Results] VAS scores decreased significantly in participants with all interventions 24 to 36 hours following application. Despite minor decrease, TSK scores were not statistically significant in any of the three groups. Stability and sway indices suggested no improvement in proprioception immediately following tape application nor 24 to 36 hours later with eyes open. Although there was no improvement immediately following tape application with eyes closed,

all groups demonstrated statistically significant improvement 24 to 36 hours later in most variables associated with stability and sway.

[Conclusions] These results demonstrated that Kinesio® Tape at the knee, hip and both alleviated pain and improved proprioception directly and through the kinestic chain but did not decrease kinesiophobia. Thus, Kinesio® Tape may be an appropriate intervention in the treatment of patients with patellar tendonitis.

[Level of Evidence] Therapy, Level 2b

[Key Words] Kinesio® Tape, Kinesiology Tape, Patellar Tendonitis, Proprioception, Balance.

4.2. Introduction

Patellar tendonitis is a debilitating condition accounting for approximately seven percent of general orthopedic conditions and affecting up to 20% of the active population.[1,2,14,46] Repetitive microtrauma over an extended period of time causes the patellar tendon to maintain a state of inflammation.[3] As a result of the constant inflammatory state, the tendon becomes susceptible to further damage, including possible tendon rupture.[12,48] Both intrinsic and extrinsic factors have been identified in the development of patellar tendonitis[1,2,14,48-55] one of which is increased dynamic knee valgum.[52] Weakness in the hip abductors and external rotators contribute to lateral collapse of the hip and medial collapse of the knee, subsequently resulting in knee valgum. Although several muscles perform hip abduction and external rotation, gluteus medius muscle weakness has been specifically identified as a risk factor.[38-42] Reducing excessive hip internal rotation and hip adduction by facilitating the gluteus medius may reduce the possibility of knee injury including patellar tendonitis.

Kinesio® Tex tape is a proposed intervention with application techniques to target injured tissue.[7] Kinesio® Tape is a therapeutic elastic tape that can be applied with different parameters to produce varying outcomes including muscle overactivation and underactivaiton,[4,69,70] pain regulation,[4,68,70,71] and improved proprioception.[4,68,70] Applications completed with tension greater than 50% are theorized to have supportive effects. Meanwhile, techniques completed with lesser tensions, applied from origin to insertion of a muscle, may have facilitatory effects.[4,7,69] Although various studies have either supported or refuted the effectiveness of Kinesio® Tape and its various applications, many limitations exist, thereby rendering its use controversial.

A strong proprioceptive system is critical in preventing injury or halting further damage to previously damaged tissue. One of the proposed benefits of Kinesio® Tape is increased proprioception.[7] The proprioceptive feedback system allows an individual to subconsciously detect the position of his or her body in space without visual input.[100,101] Mechanoreceptors in the skin, joints, and muscles send information about positioning to the brain and spinal cord.[102] Tactile effects, tension, and recoil of the tape affect subcutaneous tissue, which may impact the sensorimotor system.[101,106] Several studies have been completed supporting the use of Kinesio® Tape for proprioception in healthy participants.[72,101,105-109] However, limited research is available exploring its impact on injured tissue. Due to the adverse effects that injury has on mechanoreceptors, and subsequently proprioception, understanding how Kinesio® Tape may be applied to prevent further injury is advantageous to the treatment of patellar tendonitis.

Information regarding application of Kinesio® Tape to tendons is inadequate, with no publications specific to the patellar tendon. Available research is limited to the Achilles tendon[91,94] and peroneal tendons[99] with varying results. Due to the high prevalence of patellar tendonitis diagnoses, research specific to the treatment of this particular pathology is imperative for clinicians to make educated decisions. As the cause of patellar tendonitis is multifactorial, it is essential to treat patient-reported symptoms in addition to cause of pain, which aligns with recommendations of treating musculoskeletal pathologies by targeting aspects of the superior chain. Thus the idea of assisting the muscle fibers of the gluteus medius via Kinesio® Tape may provide clinicians with additional treatment options for those who suffer from patellar tendonitis.[38-42,115]

Evidence-based information supporting treatment recommendations, such as those published by KTAI, are essential to clinicians. While current literature outlines the effect of Kinesio® Tape on healthy tissue, there is a lack of credible research identifying its effect on injured tissue. As such, this study hypothesized that Kinesio® Tape applied utilizing the Kinesio® Taping Method to support only the knee would result in a decrease in patient-reported symptoms. Patients who received an application only at the hip would present with enhanced proprioception; however, neither pain nor kinesiophobia would decrease without the supportive application at the knee.

4.3. Methods

4.3.1. Subjects

Thirty adults (F=17, M=13) between the ages of 18 and 50 (M=22.1±1.9) volunteered to participate in this research study after being recruited through word-of-mouth, email listserv, and posted fliers. Inclusion criteria for this research study included signs and symptoms of patellar tendonitis for greater than 14 days, tenderness with palpation between the patella and the tibial tuberosity,[3,58] and a score less than 80 out of 100 on the Victorian Institute of Sport Questionnaire for Patellar Tendonitis (VISA-P) (M=57.4±13.0).[59,61,63,92] Exclusion criteria included any knee surgery within the previous six months, any pain in the ankles hips or core that would prevent a participant from completing the study, and any contraindications to Kinesio® Tape including allergy to adhesive, malignancies, cellulitis, skin infection, diabetes or fragile skin.[7] If the participant had patellar tendonitis in both knees, the more severe of the two was used for testing.

This research study was approved by the University's Institutional Review Board. Prior to inclusion, participants completed the VISA-P questionnaire and a score of less than 80 out of 100 was confirmed. Upon arrival, participants read and signed the informed consent form outlining all procedures and risks involved.

4.3.2. Study Design and Protocol

This research study utilized a pre-test/post-test design with participants randomly assigned to one of three groups. Data were collected at baseline, immediately following tape application, and 24 to 36 hours (M=25.2±1.5) after initial collection. Upon arrival to the first session, a certified athletic trainer palpated the painful area between the apex of the patella and the tibial tuberosity to confirm patellar tendonitis.[58] Participants then completed the Tampa Scale for Kinesiophobia (TSK)[116,117] and a 10-point Visual Analog Scale (VAS) specifically regarding their knee pain over the previous 72 hours.

Participant weight and height was taken as required for the Biodex Balance System (BBS). The BBS is a circular platform that allows for deviation up to 20° from neutral in all directions with an accuracy of 0.1°. Eight settings ranging from one being the least stable to eight being the most stable allow for custom protocols; the balance system was set to a level four for this study in order to provide a moderately challenging test.[99,106] The computer tracked participants' balance through a 20-second test and provided an Overall Stability Index (OSI).

OSI is a calculation of anterior-posterior (AP) deviation and medial-lateral (ML) deviation with a higher score indicating greater instability. The protocol for this study provided no visual feedback on the monitor and required all participants be barefoot. Participants were instructed to keep the platform as level as possible throughout testing. Errors were classified as opening the eyes, correcting balance by touching either hand or the opposite foot, or having the opposite knee abduct greater than 30°.

The protocol for this was in alignment with similarly published research. The following parameters were incorporated for each round of testing: 20-second test with eyes open; 20-second test with eyes closed; one-minute rest; 20-second test with eyes open, and 20-second test with eyes closed.[99,106,119,120] Because each round consisted of two trials per condition (eyes open and eyes closed), the mean for sway and stability indices were calculated. Following the baseline trial, participants were taped according to their assigned group. Once tape was applied, participants were instructed to wait in a comfortable, non-weight bearing position for 15 minutes. To analyze the immediate effects of Kinesio® Tape, a second round of BBS testing was then administered with the same parameters as previously described. Participants were then directed to continue with activities of daily living while maintaining the integrity of the tape application and to remove the tape should any discomfort or adverse reaction occur.

Once present for the follow-up session, the researcher confirmed the tape was still intact. Follow-up TSK and VAS surveys were issued to all participants with instructions to answer all prompts related to their pain and kinesiophobia over the past 24 to 35 hours. A third trial of BBS testing was conducted with the tape still intact such that the researchers could investigate the short-term effects of Kinesio® Tape on individuals who were diagnosed with patellar tendonitis.

4.3.3. Taping Technique

All Kinesio® Tape applications were applied by a Certified Kinesio® Tape Practitioner according to protocols as published by KTAI.[7] Each of the 30 subjects was assigned a number, and a random number generator was used to develop group assignments. The K group received a supportive tape application at the knee, the H group received a facilitative tape application at the hip, and the KH group received both applications. Prior to tape application, the area receiving tape was cleaned with an isopropyl alcohol wipe, excess hair was trimmed, and a non-adherent spray was applied.

The supportive tape application at the knee was completed with Kinesio® Tex Performance Plus Tape. With the participant in a seated position, the clinician cut a four to five square "I-strip" depending on the size of the participant's knee. A tape tension chart was referenced to ensure uniform application tension was referenced, and marks were placed on the participant's knee using a standard measuring tape. The middle third of the paper backing was removed and a small section at the mid-point of the tape was adhered to the patellar tendon. The participant was instructed to actively flex the knee and the middle third of the tape, approximately two to three squares, was placed at 75% tension. Both ends were then applied without tension and friction was used to adhere tape to the skin.

The facilitative hip application was completed with Kinesio® Tex Classic Tape with the participant in a side-lying position, affected side up. The CKTP cut a "Y-strip" equivalent to the distance from the ASIS to the greater trochanter of the femur. The uncut end of the tape was anchored to the ASIS and the participant was instructed to flex and abduct the hip. The taping area was then measured and marked according to the tape-tension chart, and the tails were adhered at 25% tension. The ends of the tape were placed with no tension and friction was used to adhere the tape to the skin. Participants in the knee and hip group (KH) received both tape applications.

Figure 6. Completed Kinesio® Tape applications.

4.4. Results

4.4.1. Participant Demographics

Table 14. Participant Demographics

Participant Demographics			
	K	H	KH
Age (Years)	21.9±2.1	21.7±1.8	22.7±1.9
Gender (M/F)	6/4	4/6	3/7
VISA-P (Average)	62.1±10.8	56±14.7	59.2±13.2
Time between appt. (Hours)	25±1.2	25.5±1.8	25.1±1.7

4.4.2. VAS and TSK

The first set of analyses examines the VAS and TSK scores. Descriptive statistics for these variables at the two different times and the three different taping techniques appear in

Table 15. Though the observed differences are small, the mean score declined under all conditions between the two measurements.

Table 15. TSK (29-56 points) and VAS (0-10 points) Scores at Baseline and at Follow-up.

	Baseline		Follow-up	
	TSK	VAS	TSK	VAS
H	34.30	3.35	33.50	2.70
	(6.33)	(1.76)	(3.1)	(1.48)
K	33.70	3.95	32.60	2.80
	(7.29)	(2.19)	(7.17)	(1.38)
HK	35.10	4.30	33.40	3.20
	(4.09)	(1.93)	(4.27)	(1.62)

A boxplot of the VAS scores appears in Figure 7. It shows the slight decrease in scores for all groups between the two measurements. A linear mixed effects model was estimated with TSK score as a dependent variable and fixed effects of taping technique, time, and gender, as well as a random effect for participants. Likelihood ratio tests of the full model versus reduced models were used to obtain *p*-values. For the TSK score, the effect of taping technique was not statistically significant (χ^2[2]=0.27, *p*=.873). Reflecting the small magnitude in the decrease in score over time, the repeated measure was also not statistically significant at the 5% level (χ^2[1]=2.85, *p*=.091).

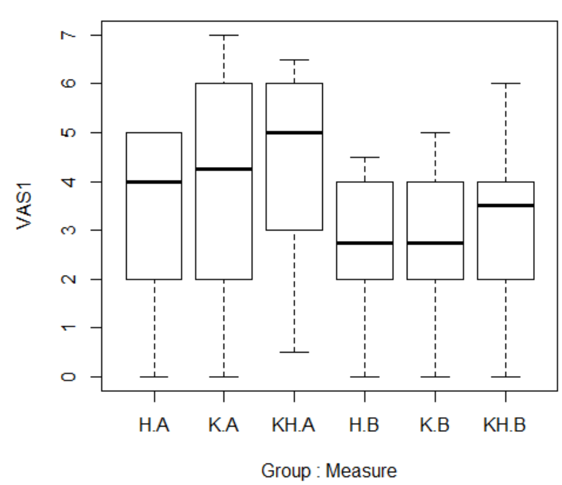

Figure 7. Boxplot of VAS scores at baseline and at follow-up.

Analogous linear mixed effects models were estimated using VAS as the dependent variable as well. For the VAS score, the effect of taping technique was not statistically significant (χ^2[2]=1.28, *p*=.527). However, the repeated measure was statistically significant (χ^2[1]=14.93, *p*<.001). The VAS score declined significantly from baseline to Day 2.

4.4.2.1. Biodex

The second set of results investigates differences in Biodex scores, based on the same factors of taping technique and repeated measurement, but in this case at three points in time. As an additional factor, the tests were collected twice: once with eyes open and once with eyes closed. A total of 6 different measurements were collected from the Biodex. The result is 54 mean outcome measures (3 taping techniques x 3 measurements x 6 measures). The results are presented in six groupings for ease of presentation.

4.4.3. Eyes Open – OVST & FBST

Descriptive statistics for these two variables appear in Table 16. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For OVST, the taping technique did not have a statistically significant effect (χ^2[2]=0.492, *p*=.782), but the time effect was significant (χ^2[2]=4.58, *p*=.101). For FBST, the taping technique did not have a statistically significant effect (χ^2[2]=1.19, *p*=.551), nor was the time effect statistically significant (χ^2[2]=5.31, *p*=.070).

Table 16. Overall Stability (score) and Forward-Back Stability (score) with Eyes Open.

	Baseline		Immediate		Follow-up	
	OVST	FBST	OVST	FBST	OVST	FBST
H	2.26	2.24	2.18	2.16	1.87	1.85
	0.44	0.44	0.09	0.09	0.55	0.55
K	2.16	2.15	2.19	2.18	2.05	2.04
	0.27	0.27	0.21	0.21	0.52	0.51
HK	2.18	2.16	2.14	2.31	2.17	2.14
	0.35	0.34	0.25	0.6	0.15	0.19

4.4.4. Eyes Open – LRST & OVSW

Descriptive statistics for these two variables appear in Table 17. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For LRST, the taping technique did not have a statistically significant effect (χ^2[2]=0.338, *p*=.845), nor was the time effect significant (χ^2[2]=3.196, *p*=.202). For OVSW, the taping technique did not have a statistically significant effect (χ^2[2]=1.46, *p*=.489), nor was the time effect statistically significant (χ^2[2]=2.49, *p*=.288).

Table 17. Left-Right Stability (score) and Overall Sway (score) with Eyes Open.

	Baseline		Immediate		Follow-up	
	LRST	OVSW	LRST	OVSW	LRST	OVSW
H	0.243	0.428	0.232	0.166	0.221	0.263
	0.135	0.69	0.148	0.149	0.139	0.507
K	0.21	0.205	0.206	0.13	0.179	0.142
	0.12	0.183	0.115	0.059	0.112	0.043
HK	0.255	0.245	0.237	0.166	0.222	0.34
	0.126	0.252	0.123	0.162	0.133	0.703

4.4.5. Eyes Open – FBSW & LRSW

Descriptive statistics for these two variables appear in Table 18. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For FBSW, the taping technique did not have a statistically significant effect (χ^2[2]=1.93, p=.380), nor was the time effect significant (χ^2[2]=2.61, p=.271). For LRSW, the taping technique did not have a statistically significant effect (χ^2[2]=0.86, p=.651), nor was the time effect statistically significant (χ^2[2]=3.34, p=.188).

Table 18. Forward-Back Sway (score) and Left-Right Sway (score) with Eyes Open.

	Baseline		Immediate		Follow-up	
	FBSW	LRSW	FBSW	LRSW	FBSW	LRSW
H	0.407	0.115	0.133	0.069	0.24	0.091
	0.681	0.129	0.147	0.038	0.501	0.01
K	0.146	0.076	0.115	0.068	0.111	0.083
	0.057	0.024	0.062	0.016	0.031	0.028
HK	0.232	0.095	0.145	0.067	0.268	0.096
	0.238	0.067	0.164	0.021	0.54	0.011

4.4.6. Eyes Closed – OVST & FBST

Descriptive statistics for these two variables appear in Table 19. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For OVST, the taping technique did not have a statistically significant effect (χ^2[2]=0.003, p=.999), but the time effect was significant (χ^2[2]=9.79, p=.007). For FBST, the taping technique did not have a statistically significant effect (χ^2[2]=0.29, p=.864), but the time effect was statistically significant (χ^2[2]=11.19, p=.004).

Table 19. Overall Stability (score) and Forward-Back Stability (score) with Eyes Closed.

	Baseline		Immediate		Follow-up	
	OVST	FBST	OVST	FBST	OVST	FBST
H	2.72	41.4	2.57	37.6	2.12	22.6
	0.81	19.8	0.6	20.1	0.43	16.3
K	2.85	50.5	2.57	35.6	2.13	23
	0.56	15.2	0.6	21.6	0.59	20.4
HK	2.46	35.1	2.47	41.6	2.47	32.8
	0.45	21.1	0.38	19.1	0.88	24.2

4.4.7. Eyes Closed – LRST & OVSW

Descriptive statistics for these two variables appear in Table 20. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For LRST, the taping technique did not have a statistically significant effect ($\chi^2[2]=0.37$, $p=.833$), but the time effect was significant ($\chi^2[2]=8.08$, $p=.018$). For OVSW, the taping technique did not have a statistically significant effect ($\chi^2[2]=0.104$, $p=.949$), but the time effect was statistically significant ($\chi^2[2]=6.35$, $p=.042$).

Table 20. Left-Right Stability (score) and Overall Sway (score) with Eyes Closed.

	Baseline		Immediate		Follow-up	
	LRST	OVSW	LRST	OVSW	LRST	OVSW
H	0.65	1.77	0.38	1.52	0.31	1.16
	0.76	1.85	0.29	1.75	0.17	0.96
K	0.56	2.56	0.4	1.45	0.28	1.11
	0.33	1.77	0.25	1.32	0.13	1.35
HK	0.42	1.51	0.37	1.12	0.4	1.43
	0.24	1.27	0.13	0.95	0.25	2

4.4.8. Eyes Closed – FBSW & LRSW

Descriptive statistics for these two variables appear in Table 21. A linear mixed effects model was estimated with Biodex score as a dependent variable. Taping technique, measurement, and gender were included as fixed effects with participant as a random effect. For FBSW, the taping technique did not have a statistically significant effect (χ^2[2]=0.19, p=.908), but the time effect was significant (χ^2[2]=15.34, p<.001). For LRSW, the taping technique did not have a statistically significant effect (χ^2[2]=0.045, p=.978), nor was the time effect statistically significant (χ^2[2]=3.24, p=.198).

Table 21. Forward-Back Sway (score) and Left-Right Sway (score) with Eyes Closed.

	Baseline		Immediate		Follow-up	
	FBSW	LRSW	FBSW	LRSW	FBSW	LRSW
H	45.1	0.539	25.9	0.306	35.2	0.747
	19.27	0.49	29.1	0.341	22.2	1.28
K	53.9	0.855	39.1	0.541	28.7	0.32
	23.9	0.62	23.8	0.5	19.61	0.25
HK	42.6	0.527	33.1	0.393	34.1	0.467
	20.26	0.519	20.82	0.214	23.44	0.488

Table 22. All Indexes with Eyes Open. (Scores)

	OVST			OVSW			FBST		
	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up
Hip	2.26	2.18	1.87	0.428	0.166	0.263	2.24	2.16	1.85
	0.44	0.09	0.55	0.69	0.149	0.507	0.44	0.09	0.55
Knee	2.16	2.19	2.05	0.205	0.13	0.142	2.15	2.18	2.04
	0.27	0.21	0.52	0.183	0.059	0.043	0.27	0.21	0.51
Hip/Knee	2.18	2.14	2.17	0.245	0.166	0.34	2.16	2.31	2.14
	0.35	0.25	0.15	0.252	0.162	0.703	0.34	0.6	0.19

	FBSW			LRST			LRSW		
	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up
Hip	0.407	0.133	0.24	0.243	0.232	0.221	0.115	0.069	0.091
	0.681	0.147	0.501	0.135	0.148	0.139	0.129	0.038	0.01
Knee	0.146	0.115	0.111	0.21	0.206	0.179	0.076	0.068	0.083
	0.057	0.062	0.031	0.12	0.115	0.112	0.024	0.016	0.028
Hip/Knee	0.232	0.145	0.268	0.255	0.237	0.222	0.095	0.067	0.096
	0.238	0.164	0.54	0.126	0.123	0.133	0.067	0.021	0.011

Table 23. All Indexes with Eyes Closed. (Scores)

	OVST			OVSW			FBST		
	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up
Hip	2.72	2.57	2.12	1.77	1.52	1.16	41.4	37.6	22.6
	0.81	0.6	0.43	1.85	1.75	0.96	19.8	20.1	16.3
Knee	2.85	2.57	2.13	2.56	1.45	1.11	50.5	35.6	23
	0.56	0.6	0.59	1.77	1.32	1.35	15.2	21.6	20.4
Hip/Knee	2.46	2.47	2.47	1.51	1.12	1.43	35.1	41.6	32.8
	0.45	0.38	0.88	1.27	0.95	2	21.1	19.1	24.2

	FBSW			LRST			LRSW		
	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up	Baseline	Immediate	Follow-up
Hip	45.1	25.9	35.2	0.65	0.38	0.31	0.539	0.306	0.747
	19.27	29.1	22.2	0.76	0.29	0.17	0.49	0.341	1.28
Knee	53.9	39.1	28.7	0.56	0.4	0.28	0.855	0.541	0.32
	23.9	23.8	19.61	0.33	0.25	0.13	0.62	0.5	0.25
Hip/Knee	42.6	33.1	34.1	0.42	0.37	0.4	0.527	0.393	0.467
	20.26	20.82	23.44	0.24	0.13	0.25	0.519	0.214	0.488

4.5. Discussion

Due to the high prevalence of patellar tendonitis in competitive and recreational athletes, research exploring treatment techniques is imperative for advancing evidence-based practice. KTAI has published several theorized recommendations regarding taping applications as a possible mitigation strategy to control pain and dysfunction. However, current research remains contradictory to the appropriate recommended application of Kinesio® Tape for individuals who present with signs and symptoms of patellar tendonitis. Additionally, researchers typically tape for reported pain, failing to consider the cause of pain. To the authors' knowledge, this study is the first to identify and compare the effects of a supportive application at the knee, a facilitative application at the hip, or both, with parameters outlined by KTAI. The inclusion of subjective, participant-reported outcomes and a functional analysis of balance is critical to enhancing clinical practice as well as future research.

Studies comparing the relationship between kinesiology tape and VAS are consistent in their conclusions that patient reported pain is decreased with short-term wear.[80,82,89,121] Marcus et al.[122] compared VAS administered at baseline and 24 hours later, in participants diagnosed with patellofemoral pain. Participants either received a Kinesio® Tape space correction application, a sham Kinesio® Tape application, a KT® Tape space correction application, or a sham KT® Tape application. Similar to the current study, VAS scores decreased significantly in 30 of 32 participants ($p<.001$), regardless of application, indicating that kinesiology tape application may decrease pain when worn for 24 hours. Results of a second study, which utilized a supportive Kinesio® Tape patellar tendon sling, [121] similar to that of the current study, also noted decrease pain in participants with patellar tendonitis. A Kinesio® Tape application, a sham application, and no tape were compared as participants completed a single leg squat test, a vertical jump test, and an isometric knee extension strength test. Although the researchers utilized a Numeric Pain Rating Scale (NPRS) as opposed to a VAS, they noted statistically significant decrease in NPRS during the vertical jump when comparing the Kinesio® Tape application to the no tape condition ($p=.05$). Unfortunately, while data were only obtained immediately following testing, results of this study support our hypothesis that Kinesio® Tape at the site of pain decreases patient reported pain. Although results of the current study do not confirm immediate decrease in pain, they do support the positive relationship between Kinesio® Tape and decreased pain with short-term wear. Based on several studies reporting similarly improved outcome measures at the site of application, a decrease in VAS scores in groups receiving the knee application was expected.[82,83,89,121] Interestingly, our results suggest the group that received tape at the hip also presented comparable results, possibly indicating kinematic chain improvements through facilitation of the gluteus medius muscle. Thus, it is possible that intervening at the hip can affect reported pain at the knee in as little as 24 hours. Further research should be conducted to consider kinetic chain theories for other musculoskeletal pathologies.

Unlike VAS outcomes, our results show TSK scores were not statistically significant for participants regardless of group assignment. Comparatively, Kurt et al.[116] identified decreased kinesiophobia with a Kinesio® Tape application targeting patellofemoral pain syndrome. The Kinesio® Tape application consisted of a VMO facilitation application and patellar tendon sling; the sham group received an application without tension. TSK scales were administered at baseline and 48 hours following application. The group who received the Kinesio® Tape application observed significant improvement of 8.2 points ($p<.001$), while the group who received the sham did not show improvement with fear of movement.[116] While we did not employ a sham technique and instead utilized a within subject model, we hypothesized that participants in the K or HK groups would report less kinesiophobia due to the relationship between pain and fear of movement.[117,123] The results of our study revealed participants in all three groups recorded lower scores on the TSK in the follow-up session. Albeit the mean scores decreased for all taping conditions, the decreases were minute and not statistically significant. Although the change in reported score for all groups (H= 0.8; K= 1.1; HK= 1.7) is far less than that of the results published by Kurt et al., we recognize the difference in methodology in terms of time as to when participants were asked to evaluate their kinesiophobia for a second time.

Proprioception is the subconscious sense of physical self-awareness as a result of joint position sense and joint position movement.[100,101] Commonly referred to as the "sixth sense," proprioception should be evaluated without the assistance of visual input.[100] It has been suggested Kinesio® Tex tape can remain on the skin for multiple days and provide sustained cutaneous input for various purposes.[7,105,124,125] Although tape may be worn for multiple days, previous research utilizing the BBS and kinesiology tape has been limited to immediate effects. Hosp at al.[106] and Farquharsen et al.[99] both noted immediate improvement in proprioception following the application of Kinesio® Tape. Protocols for both studies included taping and fatiguing healthy participants followed by immediate evaluation of proprioception. Not only did both researchers include solely healthy tissue, they failed to consider short-term effects as opposed to immediate, nor did they require participants to remove visual input. The current study noted no immediate effects following tape application with eyes open or eyes closed. However, proprioception measured 24 to 36 hours following application yielded statistically significant results in all groups with eyes closed in the majority of stability and sway indexes. Results from our study indicate that Kinesio® Tape may assist in proprioception within 24 to 36 hours of wearing the tape in subjects with patellar tendonitis. Additionally, these results highlight the critical role that vision plays in proprioception, thereby warranting future research with similar parameters.

Proprioception plays a critical role in injury prevention and prevention of further injury in previously damaged tissue.[100,101] A strong sense of proprioception is required to complete activities of daily living, but the need for this system is heightened with recreational or competitive athletic activities.[126] Participants are reliant on proprioception as they subconsciously react to variables and complete multiple tasks simultaneously.[126,127] By definition, proprioception is the awareness of where the body is in space without input from the five core senses.[101] However, very little research is completed with eyes closed parameters, which may provide a more accurate measure of dynamic activity.[127] Results from the current study suggest that proprioception tested with eyes open versus eyes closed produced varying outcomes. During short-term testing, participants in all groups demonstrated statistically significant decrease in BBS scores under almost all indexes with eyes closed. These results indicate that eyes-closed testing may be a more reliable indicator of proprioception. Future research should further explore eyes-closed balance under several parameters including extended time increments, general and sport-specific fatigue protocols, and in participants with other lower extremity injuries. Additional research will provide a more accurate representation of proprioception during recreational or competitive activities.

Few researchers have investigated the long-term implications of Kinesio® Tape on balance with factors that would yield results clinicians could consider to enhance functional performance of injured patients. One study[109] utilized the BBS to compare the effectiveness of a facilitative Kinesio® Tape application at the gastrocnemius to a sham application on proprioception at increments of 24, 72, and 120 hours. Although there were no statistically significant improvements in balance ($p=.05$), this research was completed with eyes open, and only in healthy individuals. In one of the longest methodological timeframes, researchers investigated the differences between balance training versus Kinesio® Tape application.[128] Performance was evaluated in both single- and double-leg positions with both eyes open and eyes closed parameters. While there was no statistically significant difference between groups, both improved significantly under most indices from baseline to 6-week follow-up with eyes open and eyes closed ($p<.05$). Comparable to much of the published literature, only healthy participants were included. Although data were collected at different increments, this supports results of the current study, indicating relevance of eyes-closed testing. Results of these studies cannot be generalized to injured subjects. However, in combination with the current study, they lay groundwork for further research exploring the longitudinal relationship between BBS results, kinesiology tape, and injured tissue.

The generalization of the findings of this study are limited by several design choices. First, this research was limited to those between the ages of 18-50; therefore, results cannot be generalized beyond this age range. Secondly, participant VISA-P scores varied significantly, indicating a wide range in severity of patellar tendonitis. As a result, the effects of Kinesio® Tape differed case-by-case; thus, some variance in results between individuals should be expected. Third, although injured participants were included, they were not fatigued at the time of study. While positive results have been observed with general and local fatigue in healthy tissue,[99,105] this study focused specifically on proprioception in injured subjects. Inducing fatigue in injured tissue could better imitate the effects of Kinesio® Tape during physical activity, practice, or competition. Additionally, a control group was not utilized; instead each participant served as his or her own control through baseline measurements. Due to this within subject design, the data do not allow analysis of a possible placebo effect. Finally, we did not include, utilize, or test any competing kinesiology tapes; therefore, conclusions from this research cannot be generalized outside of the specific brand of Kinesio® Tape.

4.6. Conclusions

In conclusion, a supportive Kinesio® Tape application at the knee, a facilitative application at the hip, or both may be an effective treatment for pain and proprioception in patients with patellar tendonitis. Unlike most research, which only explores results immediately after tape application, thus failing to consider possible prolonged effects, this study supports short-term use of Kinesio Tape. These short-term results may be obtained with Kinesio® Tape at the site of pain and treatment with tape through the kinetic chain. Additionally, results of this study indicate the importance of proprioception without visual aid. Kinesio® Tape for pain, cause of pain, and proprioception may be an effective treatment for patients with patellar tendonitis.

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APPENDIX A. NDSU IRB APPROVAL

NDSU NORTH DAKOTA STATE UNIVERSITY

December 5, 2019

Dr. Katie Lyman
Health, Nutrition & Exercise Sciences

IRB Approval of Protocol #HE20097, "A Comparison of Kinesio® Taping Methods for subjects with Patellar Tendonitis"
Co-investigator(s) and research team: Kathleen Gallais, Kyle Hackney

Protocol Reviewed: 11/21/2019
Protocol Status Update Due prior to: 11/20/2022

Research site(s): NDSU Funding Agency: n/a
Review Type: Expedited category # 4
IRB approval is based on the revised protocol submission (received 12/1/2019). Please use the approved consent, version received 12/1/2019.

Additional approval from the IRB is required:
o Prior to implementation of any changes to the protocol (Protocol Amendment Request Form).
o For continuation of the project beyond the approval period (Continuing Review Report Form). A reminder is typically sent approximately 4 weeks prior to the expiration date; timely submission of the report the responsibility of the PI. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

Other institutional approvals:
• Research projects may be subject to further review and approval processes.

A report is required for:
o Any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (Report of Unanticipated Problem or Serious Adverse Event Form).
o Any significant new findings that may affect risks to participants.
o Closure of the project (Protocol Termination Report).

Research records are subject to random or directed audits at any time to verify compliance with human subjects protection regulations and NDSU policies.

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,

Kristy Shirley

Kristy Shirley, CIP, Research Compliance Administrator

For more information regarding IRB Office submissions and guidelines, please consult https://www.ndsu.edu/research/for_researchers/research_integrity_and_compliance/institutional_review_board_irb/. This Institution has an approved FederalWide Assurance with the Department of Health and Human Services: FWA00002439.

APPENDIX B. INFORMED CONSENT

NDSU NORTH DAKOTA STATE UNIVERSITY
Health, Nutrition, and Exercise Science
Department #2620, PO Box 6050
Fargo, ND 58108-6050
701-231-5590

A COMPARISON OF KINESIO® TAPING METHODS FOR SUBJECTS WITH PATELLAR TENDONITIS

This study is being conducted by:
Dr. Katie Lyman, HNES Assistant Professor, Katie.Lyman@ndsu.edu, office number: 701-231-8208.
Kathleen Gallais, HNES Advanced Athletic Training Masters Student, kathleen.gallais@ndsu.edu, cell number 701-631-2846

Key Information about this study:

This consent form is designed to inform you about the study you are being asked to participate in. Here you will find a brief summary about the study; however, you can find more detailed information later on in the form.

- **Purpose of this study**: To compare the effectiveness of the Kinesio® Tape applications on proprioception in subjects with patellar tendonitis.
- **Inclusion Criteria**: Seeking both male and female participants between the ages of 18-50. Must present with signs and symptoms of patellar tendonitis including: a score of <80 of 100 on the Victorian Institute of Sport Assessment for Patellar Tendonitis (VISA-P), have experienced pain for greater than 14 days, and have pain with palpation between the patella and the tibial tuberosity.
- **Exclusion Criteria**: Knee surgery in the last six months; acute injury to the knee; and any other pain in the ankles, hips or core that may limit you from completing balance testing. If you have any allergy to adhesive, malignancies, cellulitis, skin infection, diabetes, or fragile skin you will also be excluded.
- **Risks**: Possible slight discomfort with the Kinesio® Tape application. However, if pain is reported, the session will be stopped and tape will be removed immediately. Additionally, there is possibility of fall due to the raised Biodex Balance System (BBS) platform on an uneven setting. An evaluator will be placed to steady or catch you if balance is lost.
- **Benefits**: Contribution to research that will allow Athletic Trainers and other health care professionals make evidence-based decisions regarding the application of Kinesio® Tape.
- **Time Commitment**: Two sessions separated by 24-36 hours. The first will require less than one hour, while the second will require less than 20 minutes. Maximum amount of time expected is one hour and 20 minutes.

- **Compensation**: Completion of $20 will be awarded after completion of the second session.
- **Privacy**: Privacy will be maintained throughout the study. All identifiable information will be kept locked in an NDSU office, while data collected via paper forms will be logged in a secure laptop accessible only to Dr. Katie Lyman, and Kathleen Gallais. Forms will be shredded after being logged.

Why am I being asked to take part in this study?
We are looking for 30 male or female participants between the ages of 18-50 years in the Fargo-Moorhead area with Patellar Tendonitis. You will not be allowed to participate if you have had knee surgery in the last six months; any acute injury to the knee, and any other pain in the ankles, hips or core that may limit you from completing the balance testing. Any allergy to adhesives, malignancy sites, cellulitis, skin infection, open wounds, diabetes or fragile skin are also cause for exclusion.

What will I be asked to do?
Prior to arrival, you will be asked to complete the Victorian Institute of Sport Assessment for Patellar Tendonitis questionnaire (VISA-P) and email back to the researcher. Participants must score less than 80 (of a possible 100) points in order to be considered for the study. If you meet the criteria, you will be scheduled for your first session. At the scheduled time, you will come to the Bentson Bunker Fieldhouse, Room 14, wearing loose shorts. You will be asked to read the consent form, ask any questions you may have, and sign the consent form. We will then review your completed VISA-P and confirm instance of patellar tendonitis through palpation at the knee. You will then complete the Tampa Scale for Kinesiophobia (TSK) to measure fear of movement, and a Visual Analog Scale (VAS) to measure overall pain. Height will be measured with a standard standometer, and weight will be taken on a manual scale due to requirements of the Biodex Balance System (BBS), which will be used for all active measurements. You will then proceed to the practice sessions consisting of a 20-second balance test; once with eyes open, and once with eyes closed. Following a two-minute rest, baseline measurements will then be taken as follows: two tests with eyes open, and two tests with eyes closed on the injured leg, each with one-minute rest between. Next, the assigned taping area will be cleaned, and excessive body hair will be trimmed. You will be taped with Kinesio Tape® at either the knee, hip, or both the knee and the hip based on your randomized group assignment. Fifteen minutes of rest will be given, and a second round of balance testing will be completed with the same parameters as the baseline testing. You will then be scheduled for a second appointment no less than 24 hours, and no more than 36 hours following the first.
Upon your arrival on Day 2, you will be asked if you wish to continue with testing or withdraw. If you withdraw, you will receive $10 for your participation on Day 1. If you choose to continue, the integrity of the tape application will be confirmed, and a second TSK and VAS will be administered. A final round of balance testing will be competed, and you will receive $20 compensation for your time.

Where is the study going to take place, and how long will it take?
This study will take place in Room 14 of the Bentson Bunker Fieldhouse on the North Dakota State University campus at 1301 Centennial Blvd. Fargo, ND 58102. The study will consist of

two treatment sessions with 24-36 hours between each session. The first session will take a maximum of one hour and the second session on the following day will last a maximum of 20 minutes. This research will take a maximum of one hour and 20 minutes in its entirety.

What are the risks and discomforts?
You may feel slight physical discomfort after the kinesiology tape has been applied. Because the study is being conducted on injured tissue, it is anticipated that some previous physical discomfort will be alleviated. If discomfort occurs due to the tape application, the session will be stopped, and tape will be removed upon request.
It is not possible to identify all potential risks in research; however, reasonable safeguards have been taken to minimize known risks. If new findings develop during the course of the research which may change your willingness to participate, we will tell you about these findings.
If you are known to have a sensitivity to any chemicals or adhesives or have had a violent allergic reaction to chemicals or adhesives, you should not take part in this study.

What are the expected benefits of this research?
Individual Benefits: After the application of kinesiology tape, you may feel pain relief associated with the symptoms of Patellar Tendonitis.
Societal Benefits: The results of this study will be used to offer more information to athletic trainers and other healthcare professionals with regards to treatment options for Patellar Tendonitis. The results may also be used for further investigation into the differences between Kinesio® Tape applications.

Do I have to take part in this study?
Your participation in this research is voluntary. If you decide to participate in the study, you may change your mind and stop participating at any time without penalty or loss of benefits to which you are already entitled.

Will it cost me anything to participate?
You will be responsible for providing your own transportation to and from the testing location. In the event of an emergency, you may be referred to a local care facility where you and your third-party payer (such as health insurance or Medicare) will be responsible for payment.

What are the alternatives to being in this study?
Instead of being in this research, you may choose not to participate.

Who will have access to my information?
We will keep all research records that identify you private. Your information will be combined with information from other people taking part in the study. When we write about the study, we will write about the combined information that we have gathered. We may publish the results of the study; however, we will keep your name and other identifying information private.
We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information, or what that information is. For example, your name will be kept

separate from your research records. Your name and research records will be stored in different places under lock and key. If you withdraw before the research is over, your information will be removed at your request, and we will not collect additional information about you.

How will my information be used?

The data collected will be used for statistical analysis. Collected data will not be used or distributed for future research, even if de-identified.

Can my participation in the study end early?

You may choose to withdraw from this study at any time.

Will I receive any compensation for participating in the study?

Upon completion of the second treatment session you will be awarded $20 as compensation.

What happens if I am injured because of the study?

If you are injured during the course of this study, you should contact Dr. Katie Lyman at 701.231.8208 or Kathleen Gallais at 701.630.2846. Treatment for the injury will be available including first aid, emergency treatment, and follow-up care as needed. Payment for this treatment must be provided by you and your third-party payer (such as health insurance or Medicaid). This does not mean that you are releasing or waiving any legal right you might have against the researcher or NDSU as a result of you participation in this research.

What if I have questions?

Before you decide whether you'd like to participate in this study, please ask any questions that come to mind now. Later, if you have questions about the study, you can contact Dr. Katie Lyman at 701.231.8208 or Katie.Lyman@ndsu.edu, or Kathleen Gallais at 701-630-2846 or Kathleen.gallais@ndsu.edu.

What are my rights as a research participant?
You have rights as a research participant. All research with human participants is reviewed by a committee called the *Institutional Review Board (IRB)* which works to protect your rights and welfare. If you have questions about your rights, an unresolved question, a concern or complaint about this research you may contact the IRB office at 701.231.8995, toll-free at 855-800-6717 or via email (ndsu.irb@ndsu.edu).

Documentation of Informed Consent:
You are freely making a decision whether to be in this research study. Signing this form means that

1. you have read and understood this consent form

2. you have had your questions answered, and
3. you have decided to participate in the study.

You will be given a copy of this consent form to keep.

________________________________ _______________
Your signature Date

________________________________ _______________
Your printed name Date

________________________________ _______________
Signature of researcher explaining study Date

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Printed name of researcher explaining study