The Effect of Kinesio Tape on Force Sense in People With Functional Ankle Instability

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Objective: To evaluate the effect of kinesio tape (KT) on proprioception of the ankle.

Design: Case-control study.

Setting: Controlled laboratory.

Participants: Twenty-eight subjects participated in this study: 14 subjects were in the control group (no history of ankle injuries) and 14 subjects were in the functional ankle instability (FAI) group (history of ankle injuries and a recent history of giving way).

Intervention: Subjects in the FAI group received lateral ankle sprain KT application, whereas those in the control group received no tape application.

Main Outcome Measures: Proprioception was measured using eversion force sense. This task was performed at 30% of the eversion maximum voluntary isometric contraction. Force sense was tested at baseline, immediately after KT application, and 72 hours after KT application.

Results: Results revealed a significant time by group interaction ($P = 0.03$). At baseline and immediately after KT, subjects in the FAI group had significantly more force sense errors than those in the control group. However, after wearing the tape for 72 hours, no significant differences were identified between the groups.

Conclusions: We found that after wearing KT for an extended amount of time, proprioceptive deficits were improved. After the tape application, the improvements resulted in similar conscious proprioceptive awareness in both the subjects with and without ankle instability.

Key Words: KT, lower leg, FAI

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INTRODUCTION

Proprioception contributes to human movement by providing information on the current status of the moving body part. In proprioception, input is received from the peripheral afferents including muscle spindles, joint and cutaneous receptors, and golgi tendon organs.[1] Conscious proprioception senses include measures of kinesthesia, joint position sense, and force sense.[2] Kinesthesia and joint reposition sense have been used to assess proprioceptive function at the ankle; however, force sense has received less attention.[2–5]

Force sense is a conscious proprioceptive sense that measures the ability of an individual to detect muscular force or tension.[3] Two components of force sense have been investigated; they are categorized as central factors (feed-forward mechanism) and peripheral factors (feedback mechanism). These 2 mechanisms work in unison to detect and produce desired forces.[6] One defining feature of feedback control is the capacity to correct for motor errors during the course of an ongoing movement. Movements become faster and more accurate as a function of practice, and the learner becomes less reliant on feedback control and more reliant on feed-forward control.[7,8] Functionally, a decreased ability to detect and reproduce a desired force may result in an individual's inability to appropriately stabilize a joint and likely lead to injury.[9] At the ankle, this lack of control could lead to a lateral ankle sprain or recurrent episodes of instability.[4] Functional ankle instability (FAI) is one condition that can occur after a lateral ankle sprain. It has been reported that 55% to 72% individuals who sustain a lateral ankle have been reported to have residual symptoms for weeks or years, and/or develop FAI.[10–12] Both historical and contemporary investigations have identified proprioceptive deficits as one of the primary contributing factors of FAI.[2,4,13–19]

In an effort to minimize proprioceptive deficits, researchers/clinicians have developed various treatment methods to address these deficits. Specifically, these methods are designed to improve neuromuscular control, thus decreasing the probability of reinjury and residual instability.[20] Taping or bracing of the ankle joint is one of the most common treatment interventions that have been used in a physically active population. Theoretically, application of tape or braces can stimulate mechanoreceptors and improve conscious proprioceptive sense.[21,22] Previous taping and bracing research has resulted in conflicting findings,[5,21–25] one of the primary reasons for these discrepancies is the variety of taping and bracing methods used.

One potential treatment technique that has only minimally been tested is the utilization of kinesio taping (KT) method. According to the manufacturers, the KT method uses Kinesio Tex Tape (Kinesio Holding Corporation, Albuquerque, New Mexico) and was designed to promote full range of motion and to move and stretch with the body. It can stretch up to 140% of its resting length, is porous to allow for evaporation of sweat

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and water, and the adhesive is heat activated to increase adhesion after application.[26] These characteristics allow the tape to be worn for much longer than traditional white cloth tape, sometimes up to 3 to 5 days.[26] We hypothesized that the ability to wear the tape over multiple test days will enhance the feedback process and improve proprioceptive capabilities.

Enhancing proprioceptive capabilities following an orthopedic injury continues to be a major clinical goal of ankle rehabilitation.[20] To determine if KT is effective in assisting with this process, it is essential to evaluate subjects who have a history of ankle injuries. Ideally, we would like to determine if using this taping technique on people with FAI can improve proprioceptive capabilities so that they are similar to participants who have never sustained an ankle injury. Therefore, the purpose of this investigation is to evaluate the effect of KT on force sense in the ankle.

METHODS

Subjects

Subjects were recruited from classes at a large Midwestern University. All subjects were involved in recreational activity. The control group was composed of 14 subjects (2 men and 12 women; age, 21.2 ± 2.6 years; height, 170.1 ± 9.9 cm; weight, 67.0 ± 13.7 kg) who had healthy ankles with no history of ankle injury. The FAI group was composed of 14 subjects (9 men and 5 women; age, 20.8 ± 1.4 years; height, 177.3 ± 9.0 cm; weight: 78.5 ± 12.9 kg) who had a history of an ankle sprain, reported their last giving way episode as 1 to 6 months from the testing date, and felt unstable during sports or recreational activity. All subjects completed the ankle instability instrument (AII) to determine group assignment.[27] The AII is a series of 9 yes/no questions, which can be used to identify subjects with FAI on the basis of severity of ankle sprain, frequency of giving way, and feelings of instability during activities of daily living. Subjects who scored a 5 or greater were in the FAI group, and subjects in the control group scored a zero. A point was given for each "yes" response. Examples of questions include the following: Have you ever sprained an ankle? Have you ever experienced a sensation of your ankle "giving way"? or Does you ankle ever feel unstable while walking on uneven ground? The AII was proven to be reliable when distributed on 2 separate occasions, 7 days apart to 101 subjects. Intraclass correlation coefficients (ICC) for different items on the questionnaire ranged from 0.70 to 0.98.[27] Subjects were excluded if they had a history of lower leg fracture or surgery. The Institutional Review Board of the Midwestern University approved the study, and all subjects read and signed an informed consent before beginning the study.

Procedures

All data were obtained in a sports medicine research laboratory, and subjects were tested on 2 separate days. On day 1, all subjects completed maximal voluntary isometric contraction (MVIC) testing followed by initial force sense testing. Then, subjects in the FAI group received the KT application, and subjects in the control group received no tape intervention but rested for 5 minutes. Immediately following the intervention or rest, a second force sense assessment was conducted. Day 2 was completed 72 hours after day 1 and included a third force sense assessment.

Maximal Voluntary Isometric Contraction Testing

Maximal voluntary isometric contraction was measured using a load cell (Sensotec, Columbus, Ohio), which was attached to a wall-mounted frame (Figure 1). The load cell was calibrated before data collection. Subjects were positioned in a supine position on a treatment table with arms crossed over the chest. Using a flexion stool, hips were flexed at 30 to 40 degrees and knees were flexed at 50 to 60 degrees; this set up is consistent with the previously published work related to MVIC testing before force sense testing.[28] A foam bolster was placed between the knees to prevent internal hip rotation. To prevent any hip abduction, a belt was secured around both legs at about the midthigh (Figure 1). The distal foot was secured to the load cell using a Velcro strap. The ankle was positioned at 0 degrees of plantarflexion and in subtalar neutral.[28] The subject was instructed to maximally evert the foot and hold it for 5 seconds.[28] This entire sequence was repeated a total of 3 times with a 1-minute rest period in between each trial.[28] The peak force of the 3 trials was used as the MVIC. Thirty percent of MVIC was then calculated and used as the target force for all force sense procedures.[28]

Force Sense Testing

All subjects were placed in the same position as in MVIC testing. They were instructed to produce the target (reference) force of 30% of their MVIC using a digital readout. We chose these loads because earlier testing at higher loads (50% and 75% of MVIC) demonstrated no relationship between force sense and frequency of giving way.[28] Once the desired target force was reached, it was held for 5 seconds followed by the subject relaxing his/her ankle, and then, the digital display was covered. The subject was then asked to reproduce that target force with the ipsilateral limb without visual feedback from the digital display. Once

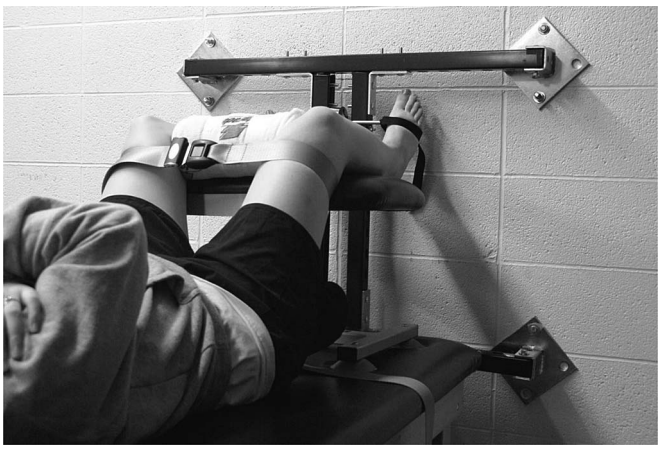

FIGURE 1. Wall-mounted frame with load cell (Sensotec). Subjects were positioned in a supine position on a treatment with hips and knees flexed, a foam bolster was placed between the knees, and a belt was secured around both legs.

the subject believed that he/she had reached the target force, he/she cued the investigator, and an electronic marking device was used to mark the data. At this point, the subject was instructed to maintain this force for 5 seconds. This procedure was repeated 3 times with a rest period of 1 minute in between trials. Reliability for this method when comparing reference forces with reproduction forces in uninjured subjects has shown to be high ($ICC_{2,1}$ = 0.85-0.89; standard error of the measurement = 0.39-0.61).[28]

Application of Kinesio Tape

Four strips of Kinesio Tex Tape were applied to the ankle according to the Kinesio Perfect Taping Manual for lateral ankle sprain.[29] The first strip began on the dorsum of the foot and traveled up the anterior aspect of the ankle and lower leg ending distal to the knee approximately over the tibial tuberosity. The second strip began on the plantar surface of the foot and traveled laterally over the lateral malleolus and lateral aspect of the lower leg. This strip terminated on the proximal lower leg over the head of the fibula. The third strip passes anteriorly across the ankle medial to lateral. The final strip began on plantar surface of the foot anterior to the second strip. It proceeded laterally ending on the anteromedial aspect of the lower leg approximately one-third of the way up the leg (Figure 2). The KT technique was only applied to the FAI group. This decision was clinically driven because a health care provider would not apply KT to an individual who did not have preexisting deficits.

Data Processing

For the force sense testing, each trial comprised a reference force followed by a reproduction force; this sequence was repeated 2 more times. Using Acqknowledge software (BIOPAC Systems, Inc, Goleta, California), the average force produced during the last second of the reference force was subtracted from the average force produced during the first second of the reproduction force. The difference between these 2 forces was identified as the trial error. The absolute value of each trial error was calculated and used for the statistical analysis. These data processing procedures are consistent with the previously published force sense research, which evaluated the reliability of force sense measures[28] and force sense deficits identified in people with ankle instability.[2–4]

Statistical Analysis

A 2-factor repeated-measures analysis of variance (RMANOVA) was used to determine if the use of KT had an effect on force sense absolute errors. This analysis included one within subject factor (time at 3 levels: baseline, immediately after tape application, and 72 hours after tape application) and one between-subject factor (group at 2 levels: control and FAI groups). A Tukey post hoc analysis was performed on any significant findings. Alpha level was set at $P < 0.05$ for all analyses.

RESULTS

The baseline mean force sense error for the control group was 0.9 ± 0.3 N, immediately after the rest period, 1.0 ± 0.3 N; and 72 hours later, 1.1 ± 0.8 N. For the FAI group, the baseline force sense error was 2.6 ± 1.0 N, immediately after tape application was 2.2 ± 1.8 N, and 72 hours after tape application was 1.8 ± 1.2 N. Results of evaluation of assumptions of normality, homogeneity of variance–covariance matrices, linearity, and multicollinearity were satisfactory. Results of the RMANOVA revealed a significant time by group interaction ($F_{2,52}$ = 3.7; P = 0.03; effect size = 0.13; power = 0.65). Results of post hoc testing revealed that at both baseline ($t_{1,26}$ = 6.1; P = 0.01; effect size = 0.58; power = 0.99) and immediately after tape application ($t_{1,26}$ = 2.4; P = 0.02;

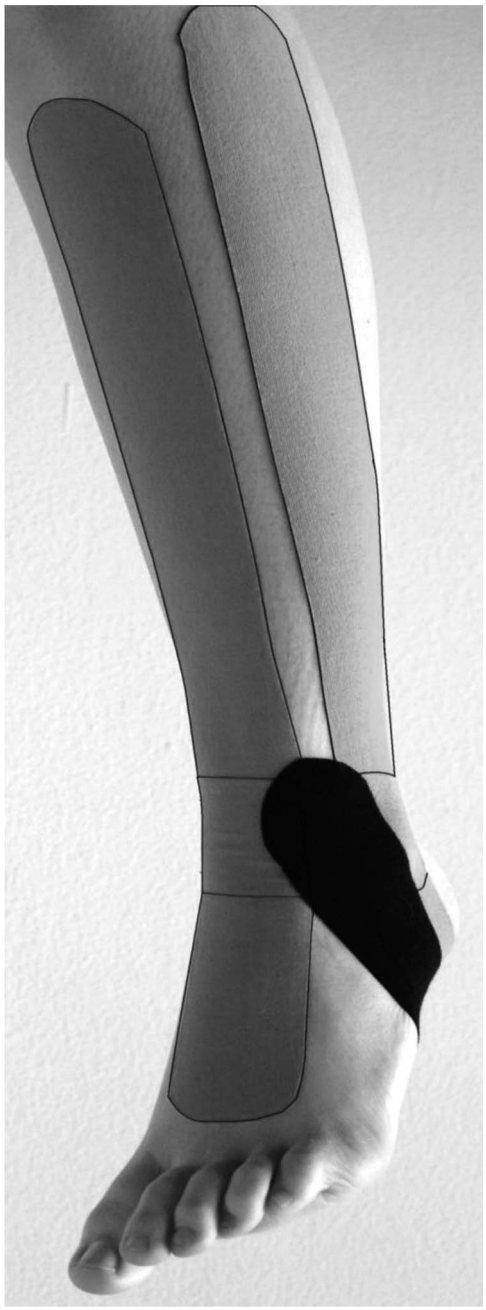

FIGURE 2. KT application.

effect size = 0.18; power = 0.64), the FAI group had significantly more errors than the control group. However, after wearing the tape for 72 hours, no significant differences were identified between the groups ($t_{1,26} = 1.7$; $P = 0.12$; effect size = 0.09; power = 0.37). In other words, after the FAI group wore the tape for 72 hours, they had decreased force sense errors, and more specifically, the magnitude of those errors in the FAI group were similar to those in the control/uninjured group (Figure 3).

DISCUSSION

The primary finding of this study was that KT improved force sense reproduction in subjects with FAI after they wore the tape for 72 hours. In essence, after 72 hours of tape application, the FAI participants who initially exhibited proprioceptive deficits had errors similar to those who have never been injured. The use of a control group in this study was important because although there was no need to apply tape to these individuals, it was important to evaluate if the use of KT could improve proprioception to the level that would be similar to those who have never sustained an injury.

The primary goal of this study was to investigate the effect of KT on proprioception on an injured population, which has been lacking in the KT literature to date. Many of the KT articles have investigated a healthy population.[30,31] For example, Halseth et al[30] concluded that KT did not improve joint reposition sense in the ankle, but the use of only healthy subjects was a major limitation in this study. It was viewed as a limitation because healthy subjects might not have had any proprioceptive deficits, subsequently making it very difficult to see any improvements after the KT application. Clinically, a health care provider would not apply KT to an individual who did not have preexisting deficits. We speculated that an "injured" population who has an actual proprioceptive deficit would respond differently than healthy subjects, which was confirmed with the results of the current study.

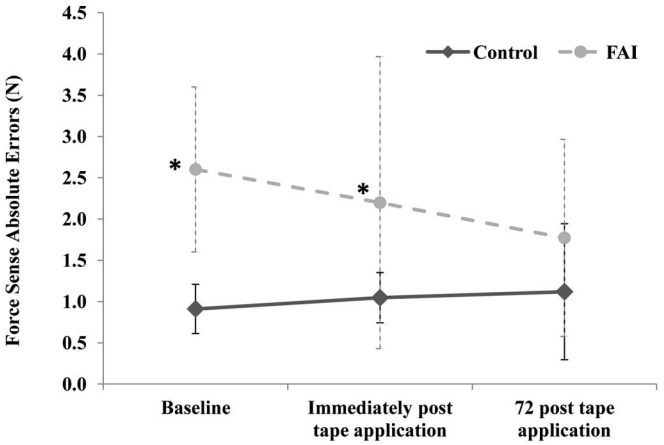

FIGURE 3. Graphical representation of force sense errors at baseline, immediately after tape application, and 72 hours after tape application. *The ankle instability group demonstrated significantly larger force sense errors at baseline and immediately after tape application compared with the control group.

One potential advantage of using KT over other forms of taping or bracing is that it can be worn continuously for several days. By wearing the tape continuously, proprioceptive stimulation is occurring constantly, versus traditional taping or bracing that is only used during athletic participation. We found that proprioceptive improvements only occurred after wearing KT for an extended time. A possible explanation for the delayed improvement in force sense errors could be related to a basic principle in motor learning. According to the theory of motor learning presented by Adams[7] in 1971, all movement is made by comparing the ongoing feedback from the limbs to a reference of correctness, which is learned through practice.[8,32,33] This reference of correctness is termed a perceptual trace. Hypothetically, once an ankle injury occurs, and the ankle proprioceptors are damaged, the central nervous system (CNS) will use whatever input remains to form a new perceptual trace. When afferent information is enhanced through the application of tape, the CNS would need to establish a new perceptual trace. It is possible that once the subjects left the laboratory and continued their normal activities, their body became more aware of the increase in afferent information and learned how to use it to establish a new perceptual trace. When the subjects were retested, they may have been more efficient at processing the afferent information and using this information to more accurately produce a desired force.

Therefore, we hypothesize that the application of KT sufficiently stimulated cutaneous receptors and mechanoreceptors within the tendons, joint capsule, and uninjured ligaments of the ankle. The increase in afferent input to the CNS improved the ability of the subjects to accurately reproduce the desired force. Clinically, an increase in afferent feedback to the body would be helpful for patients with acute ankle sprains. If proprioceptive awareness is decreased as a result of injury, increasing stimulation to the mechanoreceptors and cutaneous receptors may impact this awareness and potentially decrease the risk of a recurrent injury.

Recent investigations of this theory, using traditional white cloth tape and a variety of braces, have presented conflicting results.[5,21–25,34,35] The majority of these studies use joint reposition sense[21,23–25,35] or threshold to detection of passive motion[5,22,25] as the measures of proprioceptive status. Heit et al[21] concluded that taping decreased joint position errors in plantarflexion but not inversion. Hartsell[23] determined that the use of a semirigid brace reduced joint position errors, whereas a more flexible brace did not. Simoneau et al[25] found that tape on the ankle decreased joint position errors during non–weight-baring conditions but not during weight-baring conditions. However, Kaminski and Gerlach[24] found that neither ankle taping nor neoprene ankle brace decreased active or passive joint position errors. The main reason for these discrepancies is the diversity of methods used to evaluate proprioception and the variety of taping and bracing techniques investigated. It is clear from this sampling of research that coming to a consensus about the effectiveness of taping or bracing on proprioception is difficult.

However, the results presented in the current study and the previous study on KT done in the upper extremity offer some insight to the positive therapeutic effect KT may have on proprioception.[31] Our findings agree with Chang et al[31] who evaluated the effect of KT on force sense in the wrist flexors. Both identified an improvement in force sense errors in individuals who wore the KT. However, 2 other investigations evaluating the effect of KT on joint position sense yielded no positive outcomes.[3,30,36] It is interesting to note that the 2 studies that evaluated force sense as the conscious proprioceptive sense found positive results, whereas those studies that evaluated joint reposition sense did not. Further investigation is needed to determine if the use of KT is facilitating not only cutaneous mechanoreceptors but also other mechanoreceptors, which are more sensitive to detection with force sensing procedures.

Limitations

The magnitude of the force sense improvements should be critically reviewed. A deficit of 1 to 2 N seems small and potentially clinically unimportant. However, this value is consistent with other published force sense deficits in an FAI population.[2–4] One potential reason for the relatively low error values was because subjects were only asked to reproduce 30% of their MVIC. This percentage was used to (1) be consistent with previous research[2–4] and (2) reduce the chance of the subject becoming fatigued. Early force sense work by Jones and Hunter[37] identified that force sense errors increase as the muscle being tested is fatigued. Fatigue was not the focus of this study, but it was important to keep loads relatively low.

The lack of a taping intervention in the control participants could also been seen as a limitation. Subsequently, it is unknown if similar improvements might have been seen in these subjects if they received the tape application as well. This should be an area of future inquiry.

Future Research

Due to our research design, subjects were tested immediately after the tape was applied, which took approximately 5 minutes, and then not again until 72 hours after the initial application. Therefore, the proprioceptive improvement occurred anywhere between 5 minutes and 72 hours after the application. It should be noted that when applying the tape, it is recommended to wait at least 30 minutes before athletic participation. This period is suggested to allow for the tape to maximally adhere to the skin. It is feasible that this 30-minute period may also coincide with the time needed for the tape to initially cause a proprioceptive improvement, but these exact periods need to be further investigated.

CONCLUSIONS

This study found that applying KT to subjects with FAI resulted in decreased force sense errors after the tape was applied for several days. Clinically, we can conclude that using this tape may cause an increased awareness of muscular force and will assist patients in producing the desired amount of force during movement. This increased awareness might decrease the risk of further instability or injury. The use of KT should be considered as an appropriate treatment option when the goal is to improve proprioception.

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