A Thesis

entitled

Effects of External Ankle Taping on Lower Extremity Kinetics and Kinematics in Young Adult Males

by

Chandler Dominique Moore

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Master of Science Degree in Exercise Science with a Concentration in Athletic Training

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**Context:** External stabilizing devices serve to limit the range of motion of the involved joint. As the most common injury in collegiate athletes, ankle injuries are frequently supported by external devices such as external ankle tape. Changes in biomechanical values at the ankle may result in changes up the kinetic chain. By using external ankle tape, clinicians may be increasing the risk of pathology in the athletic population. However, no research exists to support this theory.

**Objective:** To compare the effect of external ankle taping on knee and hip kinematics and kinetics compared to no taping during an anticipated sidestep cutting task and a straight sprint task. **Study Design:** Cross-over study. **Setting:** Laboratory. **Participants:** 16 healthy males (Age: 23.1±2.6 years, Mass: 81.4±11.4 kg, height: 181.7±7.3 cm) with no history of lower extremity surgery, lower extremity injury in the past six months or any vestibular or balance disorders. **Intervention:** Participants completed both an external taping technique and a no taping condition. **Main Outcome Measures:** Three-dimensional kinematics and kinetics were collected with a 12-camera motion capture system.
and in-ground force plate. Participants completed 5 trials each of a sprint and an anticipated side-step cut with or without external ankle taping. Group means and associated 90% confidence intervals were plotted, with significance being identified when the confidence intervals did not overlap for three consecutive data points. **Results:** No significant differences in speed, kinetics, or kinematics were identified between conditions for the tasks. **Conclusion:** External ankle tape did not have a significant effect on the kinetics or kinematics in healthy adult males during a sprinting or anticipated side-step cutting task. However, the basis of the study was dependent on the assumption that ankle kinematics and kinetics would be changed. Future research should evaluate potential influences of external taping on lower extremity function in female or pathological participants.
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I would like to acknowledge Dr. Amanda Murray of the College of Health and Human Services at the University of Toledo for putting in hours of work to help me complete statistical analyses during crunch time.

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Chapter One

Manuscript

Introduction

The kinetic chain has been studied over the past 30 years and has been suggested that although kinematics of the lower extremity may stay consistent, kinetics are constantly changing.\(^1\) For example, as the moments at the hip change, moments at the knee will change, and moments at the ankle will change. This phenomenon is a result of the various muscles that cross two articulations, such as the rectus femoris, the biceps femoris, and the gastrocnemius.\(^1\)

Musculoskeletal injuries most commonly occur due to extreme changes in motion,\(^2,3\) mal-alignments,\(^3\) quick changes in direction,\(^4\) jump landings,\(^4\) sudden deceleration,\(^4\) and decreases in support from static and dynamic stabilizers.\(^5\) Lower extremity joints rely largely on musculature for dynamic stabilization.\(^5\) Dynamic stabilization is directed by the sensorimotor system,\(^6,7\) which can be compromised during the time of injury. Damage to proprioceptors decreases the functional ability of dynamic stabilizers, thus predisposing subjects to further injury.\(^5\) As a result, health care providers such as physicians, athletic trainers, and physical therapists use external devices or braces to stabilize the joint.

External stabilizing devices serve to limit the range of motion of the involved joint. As the most common injury in collegiate athletes\(^8\), ankle injuries are frequently supported by external ankle devices. Ankle taping has been found to decrease pronation,\(^9,10\) supination,\(^9,10\) and eversion\(^10\) during a side-step cutting task. As previously reported, changes in the kinematics of the foot may result in changes of forces on joints.
up the kinetic chain due to biarticular muscles. However, research pertaining to injury rates do not necessarily confirm these findings.\textsuperscript{11} One specific research study reported that knee injury rates were not significantly different for braced subjects and control subjects in a randomized controlled trial completed over one high school football season.\textsuperscript{12}

One form of external stabilization of the ankle is external ankle taping. Existing research pertaining to external ankle taping has focused primarily on changes in the ipsilateral ankle. Thus, research has shown that external ankle tape can decrease the amount of inversion at the ankle.\textsuperscript{13,14} For example, in a study by Pederson, et al., the researchers found that externally taping the ankle could decrease passive ankle inversion by 4.7° before and after exercise.\textsuperscript{13} Another study by Udermann et al. found similar results and even went further to determine that external ankle taping methods were more effective than under the shoe ankle taping methods in limiting range of motion of the ankle.\textsuperscript{14} In the Udermann study, differences in active inversion and eversion at baseline testing and 5-minutes following exercise were significant when external ankle tape job was compared to an under the shoe tape job.\textsuperscript{14} Speculations have been made that injury may result due to fixation of the foot. Currently, no research can be found explaining the specific biomechanical changes at the knee or hip specific to external ankle tape. Although research has suggested that there is a 5% higher occurrence rate for noncontact ACL injury in the NFL, it has failed to determine the changes that caused these injuries.\textsuperscript{15} Further, researchers have not examined what other injuries may occur besides ACL tears. Considering the research that suggests the ROM at the ankle is limited more by external ankle tape than it is by ankle taping or bracing, it is hypothesized that the changes at the
ankle resulting from external devices change forces at the knee and hip significantly enough to predispose the athlete to injury.

The purpose of this study is to examine the effects of external ankle tape on the kinetics and kinematics at the ankle, knee, and hip during a straight sprint task and a side-step cutting task. Mechanisms of injury for knee injuries, especially noncontact ACL injury, commonly include abnormal lower limb orientation such as knee in/toe in, knee out/toe out, and hyperextension. Additionally, loading of the knee during abduction and anterior shearing forces are common mechanisms of injury. These mechanisms can be recreated by athletes during more functional tasks such as side-step cutting tasks or straight sprinting tasks, resulting in these impairments.

Methods

**Design** We completed a descriptive laboratory study with a cross-over design. Our independent variables were task (anticipated side-step cut to the right and straight sprint) and condition (no external ankle tape and external ankle tape. The dependent variables were ankle, knee, and hip frontal, sagittal, and transverse plane kinematics and kinetics during the stance phase of the task and vertical, anteroposterior, and mediolateral ground reaction forces.

**Subjects** Sixteen healthy recreationally active male subjects between the ages of 18-30 years old completed this study. (Table 1) Convenience sampling was used to recruit participants from the University of Toledo and the Greater Toledo Area. Participants were eligible to complete the study if they had previous experience in cutting sports such as football, soccer, basketball, voleyball, tennis, or lacrosse and a score of five or more on the Tegner Activity Scale. Participants were healthy individuals without
a previous history of lower extremity injury requiring surgery within the last six months and any lower extremity injury still causing pain or dysfunction. Additional exclusion criterion was any vestibular balance disorder.

**Instrumentation** Kinematics and kinetics were collected using Cortex 3-D Motion Analysis software (Version 5.5.0, Santa Rosa, CA) and AMTI force plates (OR5-6, Advanced Mechanical Technologies Inc., Watertown, MA). Kinematics were collected via 12 Cortex 3-D Motion Analysis Inc Eagle cameras operating at a rate of 200Hz for both control and experimental sprinting and side-step cutting maneuvers. Force plates, with a sampling rate of 1000Hz, were used to determine ground reaction forces, as well in determining joint kinetics. Time for each trial was collected using custom laboratory timing gates. Laboratory set up can be found in Figure 1.

**Figure 1. Laboratory Set up**

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**Consent and General Health History** All participants were required to attend a single testing session during which they completed a straight sprinting task and an
anticipated side-step cutting task. Upon arrival at the University of Toledo Main Campus’ Musculoskeletal Health & Movement Science Laboratory, all participants read and signed consent forms approved by the University’s Institutional Review Board. Following consent, the participants completed a general health history form that included height, weight, sex, and age. In addition, the participants were asked to note specific health issues under headings of “general”, “neurological”, “cardiovascular”, and “general orthopedic”. Participants also provided information pertaining to how familiar they were with external stabilizing devices.

**Familiarization** Prior to marker set up, participants were fitted with standard shoes (Asics Gel-Contend 2, Irvine, CA) and completed no more than 5 practice trials of each task. Each participant completed familiarization and testing trials wearing a lab standardized shoe. Forty-two reflective markers were secured using adhesive tape for each subject on the following anatomical marks: sternal notch (1), C7 (1), inferior angle of the right scapula/T10 (1), bilateral acromioclavicular joints (2), bilateral anterior superior iliac spines (2), bilateral posterior superior iliac spines (2), bilateral greater trochanters (2), bilateral thigh cluster (4 for each leg) to the mid-antertolateral thigh, lateral femoral condyles (2), bilateral medial femoral condyles (2, static trial only), bilateral shank cluster (4 for each leg) to the lower third of the antertolateral shank, bilateral medial malleoli (2, static trial only), bilateral lateral malleoli (2), bilateral 2\(^{nd}\) metatarsal heads (2), bilateral calcanei (2), and bilateral bases of the 5\(^{th}\) metatarsal. Holes were cut in the shoes in order to place the calcaneus sensor directly on the skin.\(^{20}\) Both the markers on the base of the 5\(^{th}\) and 2\(^{nd}\) metatarsal heads were secured to the shoe with leukotape. Marker set up was completed by the same individual for each testing session.
**Set up** The force plate was six meters from the starting position which was denoted by a tape marker. A box was taped around the force plate in order to help the investigator and participant to see the force plate. Participants were asked to plant their foot inside the taped box for the sprinting task and inside the taped box at a 45° angle for the side-step cutting task. Participants were asked to maintain a speed between 3.5-5.0 m/s, which was confirmed by two sets of timing gates set up 0.914 meters from the start position and 6.99 meters from the start position. These distances were determined during pilot testing to allow sufficient space to accelerate to the required speed. In addition, the distances allowed for the participants to complete the task in the allotted space.

**Testing Procedures** Prior to testing trials each subject completed two static trials during which they stood with feet shoulder width apart and arms held straight out in the middle of the force plate for five seconds. Medial markers (medial malleoli and medial femoral condyles) were removed and a dynamic trial was completed involving three seconds of marching in the middle of the force plate.²¹

Condition order was randomized prior to the start of the session by a third-party investigator via random number generator. Order of the cutting and sprinting tasks was also randomized and counterbalanced. For the purposes of this study, the left leg was used as the plant leg for all participants. Those participants in the control first group initially completed five trials of a straight sprint and five trials of an anticipated side-step cut in a randomized order without external ankle tape. Straight sprinting trials involved maintaining a speed of 3.5-5.0 m/s from the start position to the second timing gait. Participants were instructed to hit the force plate for each trial, with their entire foot of the involved limb in the taped box. For the anticipated side-step cutting task, participants
were to approach the force plate at the predetermined speed, plant on the left foot and step with the right foot. Cutting angle was 45°, so the participants were instructed to point their left toes towards the top right hand corner of the force plate box. Both activities were anticipated, so participants were told prior to each trial which activity to perform. After the first ten trials were complete, external ankle tape was then applied by the same individual to the left foot of the subject. The participants were allowed three to five additional familiarization trials following application. Ten more trials were then completed in a randomized order with the intervention applied. Procedures for the intervention first group were identical, but for the fact that the intervention trials were recorded first.

**External Ankle Tape Technique** One layer of elastic tape (PowerFlex, Andover Healthcare Inc, Salisbury, MA) was applied as underwrap. One and a half inch tape (Cramer 950 Porous Athletic Tape, Cramer Products Inc, Gardner, KS) was used for the external ankle tape technique. The individual taping the subject was sure to overlap tape by half-width. Three anchor strips were used at both the proximal and distal ends with 2 stirrups running medial to lateral and additional alternating anchor strips. Next, medial and lateral heel locks were used in an alternating fashion totaling 4 heel locks. Two figure-8’s were applied starting medially, and finishing strips were used running from the proximal anchor strips to the distal anchor strips. In order to allow for proper collection of visual 3-D, heel locks and figure eights were applied while avoiding the calcaneal marker. The calcaneal marker was placed on each participants’ skin to avoid results representing shoe motion. For the purpose of this study, holes were cut in the posterior aspect of the shoe to expose the calcaneus. The treads of the shoe were avoided during
taping, with the tape running through the midsole of the standardized shoe. A standardized shoe was used to eliminate variability in findings due to interactions between different shoe treads during the straight sprint and side-step cutting tasks.

**Data Processing** Kinematic and kinetic data were filtered at a cutoff frequency of 12Hz using a fourth order, low-pass Butterworth filter. A static trial was collected of each subject in the anatomical position and used to calculate lower extremity joint centers using Visual 3D software (Version 6.0, C-Motion, Inc, Germantown, MD). Joint angles and joint moments were calculated in all three planes using Visual 3D. Ankle, knee, and hip angles were defined as the distal segment relative to the proximal segment and trunk angles were defined as the trunk segment relative to the global coordinate system. Joint moments were calculated using an inverse dynamics approach and were expressed as internal joint moments normalized by body mass and height (Nm/kg*m). Peak joint angles and joint moments were identified and extracted from the stance phase which was defined as the period from initial contact (vGRF exceeded 10N) to toe off (vGRF fell below 10N). Peak joint angles and moments were averaged over successful trials for each condition and used for analysis.

**Statistical Analysis** A time series analysis was used to compare values in all three planes of motion looking at both moments and angles for the hip, knee and ankle, as well as GRF for both control and experimental data during each activity. The analysis was completed during the stance phase of the support leg, specifically from heel contact to toe off for a total of 79 control side-step cuts, 77 treatment side-step cuts, 74 control sprints and 73 treatment sprints. Mean values were graphed in addition to 90% confidence intervals for each condition and activity. Significant differences were
identified when the confidence intervals did not overlap for more than 3 consecutive data points. Paired t-tests were used to determine significance in jogging speeds between conditions during both tasks at a significance level of 0.05.

**Results**

The demographics for the sixteen participants are reported in Table 1. There were no differences in speed (Table 2) between control and experimental groups for both a side-step cut (p=0.07) and a straight sprint (p=0.45). No significant differences were found for sprinting kinetics or kinematics at the ankle, knee, or hip between control and experimental groups (Figure 2 and Figure 3, respectively). No significant differences were found for cutting kinetics (Figure 4) and kinematics (Figure 5) at all three joints.

**Table 1. Demographics**

<table>
<thead>
<tr>
<th></th>
<th>N=16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>23.125±2.6045</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>81.406±11.4051</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>181.769±7.3146</td>
</tr>
<tr>
<td>Subjects with external tape experience</td>
<td>1</td>
</tr>
<tr>
<td>Subjects with tape/brace experience</td>
<td>6</td>
</tr>
<tr>
<td>Tegner Activity Scale</td>
<td>6.813±1.4245</td>
</tr>
</tbody>
</table>

**Table 2. Task Speed (m/s)**

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Tape</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprint</td>
<td>4.31±0.42</td>
<td>4.29±0.42</td>
<td>P=0.45</td>
</tr>
<tr>
<td>Cut</td>
<td>4.17±0.35</td>
<td>4.11±0.30</td>
<td>P=0.70</td>
</tr>
</tbody>
</table>

Speeds are reported as mean ± standard deviation.
Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in NM/kg, with green and red curves representing control and experimental groups, respectively.
Figure 3. Ankle, Knee, & Hip Sprinting Kinematics with 90% Confidence Intervals

Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in degrees (°), with green and red curves representing control and experimental groups, respectively.
Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in NM/kg, with green and red curves representing control and experimental groups, respectively.
Figure 5. Ankle, Knee, & Hip Cutting Kinematics with 90% Confidence Intervals

Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in degrees (°), with green and red curves representing control and experimental groups, respectively.
Discussion

Overall, we found no significant differences between external ankle tape and a non-supported ankle during either task when examining time series graphs from heel contact to toe off. Our original hypothesis was that external ankle tape would be detrimental to the biomechanics of the hip and knee during a side-step cutting task and straight sprint task. These specific tasks were used as they simulate tasks used in athletic competition hypothesized to put athletes at risk of injury.2-5 Previously, external ankle tape has been suggested to significantly limit static range of motion of the ankle.13,14

External Ankle Tape The basis of this study was dependent on the assumption that external ankle tape would alter ankle joint motion and moments in the sagittal, frontal and transverse planes during the two tasks. However, this study found no differences in ankle biomechanics. Previous research pertaining to external ankle tape is scarce, but a few studies have shown external taping to significantly decrease inversion13,14 and plantar flexion14 when compared to a non-supported ankle. The inconsistency between previous research and this study may stem from the data collection procedures. Both research studies involved collecting static range of motion measures on an inversion platform to determine the restrictions at the ankle.13,14 These restrictions were not carried over into the dynamic side-step cut and sprinting tasks. Furthermore, both previous studies found that inversion was limited to anywhere between 18-23° while using external ankle tape.13,14 Averaged peak values for the control cut and control sprint in the present study were 17° and 8°, respectively. Since these values were lower than the maximum amount of inversion accomplished while utilizing external ankle tape,13,14 it is
possible that the amount of inversion required during this tasks is not enough to elicit restrictions.

We hypothesized the lengthened moment arm at the subtalar joint would increase the stability of the joint. However, the evertor muscle group is suggested to be the most effective stabilizer of the ankle in comparison to high top shoes, athletic tape, or orthoses. A smaller moment arm, closer to the joint was more restrictive in limiting inversion and eversion. It is possible that applying external ankle tape, as in this study, removes the proprioceptive component associated with the traditional under the shoe ankle tape or brace, therefore resulting in less joint awareness and stability.

**Sprinting Kinetics and Kinematics** Outcome measures for sprinting kinetics and kinematics displayed the smallest amount of discrepancy in comparison to related research. Time series curves for the current research study mimic the shape of normal sprinting curves. We hypothesized that hip and knee moments and angles would be increased in comparison to control data, however this was dependent on the decreased moments and angles at the ankle which were not displayed. During a sprinting task, most of the motion in the ankle occurs in the sagittal plane, whereas the external ankle taping technique has been suggested to restrict motion in the frontal and transverse planes. Without much motion in these planes during a sprinting task compensations were not necessary at the proximal joints to account for changes at the subtalar joint, thus explaining similarities between control and experimental data.

Furthermore, a couple research studies concluded that the use of external stabilizing devices (ankle tape) actually have protective properties such as decreased peak internal rotation moments and peak knee varus moments as well as decreased knee
flexion at initial contact\textsuperscript{10,26} which are all impairments associated with knee injury. These changes have been identified in both a sprinting task and a jump landing task.\textsuperscript{10,26} Although the current study did not display the protective mechanisms described by these researchers, there was no change consistent with an increased risk of injury. However, previous research studies do not align with one another. Additional research displayed no effect on knee kinetics due to ankle bracing on linear movement, which aligns with our study.\textsuperscript{27} It’s quite possible that these differences can be attributed to the variety of external stabilizing device being used.

**Cutting Kinetics and Kinematics** Changes in kinetic time series curves throughout the stance phase of a side-step cut are consistent in both the external ankle tape and control conditions with some previous research looking strictly at a side-step cut.\textsuperscript{28} Although the shape is similar, the curves from this particular study displayed adduction moments compared to the abduction moments found in similar research. These adduction (varus) oriented moments at the hip and knee are common impairments for knee injury.\textsuperscript{10} This aligns with previous theories that a side-step cut is more dangerous than a straight sprint,\textsuperscript{29} however external ankle tape had no effect. Differences in between the current research study and results found by Houck, et al. likely exist due to the orientation of foot at heel contact.\textsuperscript{28}

Although the hypothesis was that kinetic forces on the knee and hip would increase, other external stabilizing devices have been previously suggested to decrease the kinetics.\textsuperscript{10,27} Ankle taping decreased internal rotation moment and varus moment in a side-step cut of 45°.\textsuperscript{10} Similarly, ankle braces reduced medial/lateral forces during a 90° cut.\textsuperscript{27} West et al. theorized that the decreased inversion and eversion at the ankle increase
frontal plane control of the whole lower extremity, including the frontal plane forces on
the knee.\textsuperscript{27} Once again, it is possible that these protective mechanisms were not seen at
the knee in the current study due to absence of differences in ankle kinetics and
kinematics.

Previously, kinematic values at the ankle\textsuperscript{30} and knee\textsuperscript{27} during a side-step cut with
the use of external stabilizing devices had been the same compared to control groups.
This is consistent with the findings involving external ankle tape. Recent evidence
supports that side-step cuts with external stabilizing devices result in increased knee
internal rotation and abduction angles.\textsuperscript{31} However, it should be noted that these previous
findings were only identified in female participants.\textsuperscript{31} Females have been shown to have
greater abduction, as well as knee flexion than males during a cutting task.\textsuperscript{32} This fact
may help explain kinematic differences between research studies. Variations in
stabilizing device, shoe type, surface, speed, and foot position at initial contact may also
be contributing factors to these disagreements. It is unlikely that results relating to one
stabilizing device can be generalized to all external stabilizing devices, emphasizing the
need for further research.

GRF Previous literature looking at ground reaction forces is inconsistent in
suggesting effects of external stabilizing devices. Braces showed no differences in ground
reaction forces\textsuperscript{33}, while some seemed to decrease the medial/lateral ground reactions
forces.\textsuperscript{27} These researchers agree that medial and lateral ground reaction forces are
greater during a cutting task than during a linear sprinting task, which is consistent with
the current research findings.\textsuperscript{27}
Clinical Implications The results of this research study suggest that the proprioceptive effect of ankle bracing does not necessarily carry over to external ankle tape. It may be more beneficial to employ the use of ankle bracing prophylactically than to use external ankle taping. However, there are neither any perceived positive effects nor negative effects of external ankle taping on ankle, knee, or hip biomechanics. It is important to note that these implications are based off a controlled laboratory study using healthy male participants. These results may not be generalizable to a more game like situation.

Limitations Although no differences were revealed between conditions, there are a few things to consider. The research study was based on the assumption that the external taping technique would result in an attenuation of kinematic and kinetic values at the ankle resulting in increased values up the kinetic chain. This assumption was not satisfied; thus, the results of the study are limited. The cutting task was completed at a 45° angle, which has the potential to limit the results. While foot placement on the force plate was controlled to a 45° angle, it is possible that athletes complete a side-step cut with varying foot placement. Speed for each trial was chosen in regards to available space, as well as simulation of game like situation. However, it is possible that the speed was not fast enough to result in significant differences, as theoretically faster speeds would result in larger forces. It is possible that there were inconsistencies between clinicians in previous research studies in regards to taping techniques; however, we used a technique previously reported and limited the taping to one investigator.

Future Research There is not much consistency when comparing the results of this research study with previous research as well as comparing these previous studies
with each other. This suggests the need for future research scrutinizing the effects of external stabilizing devices on lower extremity biomechanics while eliminating various confounding variables. Researchers should look at the relationship with external ankle tape and the environment. For example, different playing surfaces and shoe types (cleats, turf shoes, etc.) may influence the kinetics and kinematics differently. It is essential to create a more game like environment as well as possible in the laboratory setting. Unanticipated cutting tasks can be researched with the effect of fatigue and varying foot strike patterns. A gap in the research exists in regard to the effect external ankle taping may have on the kinetics and kinematics in individuals with acute ankle injury or chronic ankle instability. Overall, there is lack of research pertaining to external ankle tape which makes it difficult to make suggestions regarding the intervention.

**Conclusion** In summary, there were no significant effects of external ankle tape on biomechanics at the ankle, knee, and hip during a side-step cut or sprinting task. Identifying the effects of external ankle tape on biomechanics in more game like situations may help to reduce the risk of lower extremity injury. Further research is needed in order to suggest possible effects of external ankle tape and other external stabilizing devices.
References


23. Drewes L, Lee, YS, McKeon, PO, Paolini, G, Kerrigan, DC, Hertel, J. Side-to-side Comparisons of Ankle Kinematics During Gate Among Individuals with


Appendix A

The Problem

Problem Statement

The problem is lack of research pertaining to the biomechanical changes external ankle tape causes in the lower extremity during a side-step cutting maneuver.

Primary Research Questions

1. Does external ankle tape change hip flexion during an anticipated side-step cutting maneuver?
2. Does external ankle tape change hip flexion during a straight sprint?
3. Does external ankle tape change hip moment in the sagittal plane during an anticipated side-step cutting maneuver?
4. Does external ankle tape change hip moment in the sagittal plane during a straight sprint?
5. Does external ankle tape change knee flexion during an anticipated side-step cutting maneuver?
6. Does external ankle tape change knee flexion during a straight sprint?
7. Does external ankle tape change knee moment in the sagittal plane during an anticipated side-step cutting maneuver?
8. Does external ankle tape change knee moment in the sagittal plane during a straight sprint?
9. Does external ankle tape change knee moment in the frontal plane during an anticipated side-step cutting maneuver?
10. Does external ankle tape change knee moment in the frontal plane during a straight sprint?

11. Does external ankle tape change knee moment in the transverse plane during an anticipated side-step cutting maneuver?

12. Does external ankle tape change knee moment in the transverse plane during a straight sprint?

13. Does external ankle tape change peak ground reaction force during an anticipated side-step cutting maneuver?

14. Does external ankle tape change peak ground reaction force during a straight sprint?

**Experimental Hypotheses**

There will be an increase in hip flexion angle, hip moment in the sagittal plane, increase in hip internal rotation angle, an increase in hip transverse plane moment, increase in knee flexion angle, knee moment in the sagittal plane, an increase in knee abduction angle, an increase in knee moment in the frontal plane, an increase in knee internal rotation angle, an increase in knee moment in the transverse plane, as well as a decrease in ankle angles values in all planes, a decrease in ankle moment in all planes and an increase in mediolateral ground reaction forces during both tasks.

**Assumptions**

1. The subjects are using maximal effort during tasks

2. The subjects have similar experience

3. The subjects are performing the maneuver correctly

4. Marker placement is completed correctly
5. The external ankle taping technique will attenuate range of motion and forces at the ankle

Delimitations

1. The study is limited to males
2. The study is limited to ages 18-30 years old
3. The subjects will have no previous injury to the lower extremity in the past six weeks
4. The subjects will have no previous injury to the lower extremity requiring surgery in the past six months
5. The subjects will wear the same shoes

Limitations

1. There were no significant restrictions at the ankle
2. There may have been variances in cutting angle
3. The speed may not have been fast enough to elicit forces
4. There is no gold standard in external ankle taping technique

Operational Definitions

1. Anticipated- Awareness of direction of cut prior to start of the task.
2. Side-step cutting maneuver- Planting the contralateral foot to the direction the subject is supposed to go at a 45° angle and using the ipsilateral foot to move in the desired direction.
3. Kinematics- The component of biomechanics focused on the motion of objects without consideration of the forces responsible for the motion.
4. **Kinetics** - The component of biomechanics focused on the forces acting on the joints and ground reaction forces.

5. **External ankle tape OR Spat Tape** - Intervention involving applying medical tape to the outside of the shoe in order to limit ankle range of motion.

6. **Subject, Participant or Athlete** - Male between the age of 18 and 30 years old with experience in cutting sports such as football, soccer, basketball, volleyball, tennis or lacrosse.

**Significance of Study**

Lower extremity injuries account for 53.8% of game injuries and 53.7% of practice injuries in collegiate athletes.¹ Of these injuries, ankle ligament sprains are reported at the highest frequency, with 27,117 incidences reported from 1988-2004 in just one research study.¹ In order to combat these soaring numbers, external stabilizing devices are used prophylactically. However, researchers suggest that this prophylactic use may put athletes at risk. When kinematic and kinetic values are changed at one articulation, articulations up the kinetic chain will accommodate to this adjustment.² The potential outcome is an increase in knee and hip ligamentous injury. Looking specifically at the knee, 38% of noncontact ACL injuries in the NFL from 1989-1993 occurred when athletes were using external ankle tape.³ With the cost of ACL reconstructions around one billion dollars per year⁴ and the average return to play between six and nine months, it is important that clinicians are not putting athletes at a higher risk for such injuries. This study identifies the specific changes at the knee and hip resulting from the use of external ankle tape that can contribute to injury.
Appendix B

Literature Review

Anatomy

Lower extremity anatomy involves three joints that consist of various bones, ligaments, and muscles necessary for normal ambulation.

Ankle The ankle complex consists of three articulations; the talocrural joint, the subtalar joint, and the distal tibiofibular syndesmosis. At the talocrural joint the tibia and fibula are joined with the talus. The close-fit arrangement of the talocrural joint allows for dorsiflexion and plantar flexion motion in the sagittal plane.\(^5\) Just distal to the talocrural joint lies the subtalar joint, also known as the talocalcaneal joint. As its name suggest, the talocalcaneal joint is the articulation of the talus and the calcaneus. Similarly to the talocrural joint, the subtalar joint allows motion in a singular plane and accounts for eversion and inversion of the foot.\(^5\) Finally, the distal tibiofibular joint contains the tibia, the fibula, and the syndesmosis that joins them together. All three of the joints that make up the ankle complex function in allowing pronation and supination of the foot.

The ankle complex is surrounded by a joint capsule in which ligaments present as thicken bands of the joint capsule. These thickened bands are necessary in limiting the translation of one bone on another at any three of the joints of the ankle complex. There are three major ligaments of the lateral ankle which include the anterior talofibular ligament (ATFL), the posterior talofibular ligament (PTFL), and the calcaneofibular ligament (CFL). The ATFL functions mainly in limiting plantar flexion, but is also strained during inversion and internal rotation. Just posterior to the ATFL, the CFL is strained most when the foot is dorsiflexed, inverted, and externally rotated. Function of
the PTFL is more complex than that of the ATFL and CFL. The PTFL is strained both in extreme dorsiflexion and extreme plantar flexion. Although the PTFL does not limit inversion or eversion, it functions in limiting internal rotation of the talus.\(^6\)

The ligaments of the medial ankle are collectively known as the deltoid ligament. The deltoid ligament includes the anterior tibiotalar ligament (ATTL), the tibionavicular ligament (TNL), the tibiocalcaneal ligament (TCL), and the posterior tibiotalar ligament (PTTL). As a whole, the deltoid ligament limits plantar flexion, external rotation and eversion.\(^7\)

Musculature of the ankle is just as important as ligamentous structures in stabilizing the ankle complex. Specifically, the ankle evertors are vital in limiting inversion of the ankle, which is the most common mechanism of injury for lateral ankle sprains along with plantar flexion.\(^8\) Muscles that mainly contribute to eversion of the ankle are the peroneus longus and the peroneus brevis. These can be found in the lateral compartment of the lower leg. According to Ashton-Miller et al. (1996), the evertors contribute to passive stability 3.3 times more than ankle tape and 6.1 times more than three-quarter top shoes.\(^9\) Similar research has shown that the peroneus longus was activated the most during balancing along the frontal axis. This same study looked at activation of the tibialis anterior, medial gastrocnemius, and lateral gastrocnemius. Activation was found significantly greater in the diagonal axis, sagittal axis, and diagonal axis for each muscle respectively.\(^10\)

**Knee** The knee is comprised of three different articulations that allow for the necessary ranges of motion. These joints include the tibiofemoral joint, tibiofibular joint and the patellofemoral joint. The tibiofemoral joint has three degrees of freedom; flexion
and extension, internal and external rotation, and abduction and adduction. Although the patellofemoral joint does not necessarily account for motion at the knee it is still vital to the function of the joint. The patella functions in increasing the mechanical efficiency of the quadriceps during knee extension.

Both the cruciate ligaments and the collateral ligaments contribute to the stability of the tibiofemoral joint along with the menisci. Cruciate ligaments of the knee include the anterior cruciate ligament (ACL) and the posterior cruciate ligaments (PCL). The ACL runs from the anteromedial intercondylar eminence of the tibia to the medial wall of the lateral femoral condyle. An intact ACL functions in preventing anterior translation of the tibia on the femur as well as restraining anterior sheer forces on the knee, internal rotation of the tibia on the femur, external rotation of the tibia on the femur, and hyperextension. In contrast to the ACL, the PCL runs from the posterior tibia to the lateral side of the medial femoral condyle. The PCL limits the amount of posterior tibial translation on the femur with the help of other posterolateral structures, like the lateral collateral ligament (LCL). Without the PCL, posterior tibial translation is at its greatest in flexion.

The collateral ligaments of the tibiofemoral joint restrain motion along the sagittal axis. The medial collateral ligament (MCL), which runs from the medial epicondyle of the femur to the medial aspect of the tibia, restricts valgus motion and external rotation at the tibiofemoral joint. The LCL connects the lateral epicondyle of the femur to the fibular head. Function of the LCL is similar, but opposite, to that of the MCL. As such, the LCL resists internal rotation and varus motion at all degrees of knee flexion.
The medial and lateral menisci are necessary to aid the cruciate and collateral ligaments in keeping the tibiofemoral ligament stable. Research suggests that both the lateral and medial menisci contribute to anterior tibial translation (ATT) when the ACL is taken out of the picture. While the medial meniscus was more effective in limiting ATT during a lachmans, the lateral meniscus was more effective in limiting ATT during pivoting motions.\textsuperscript{16} The medial meniscus is more effective when paired with ACL in limiting ATT than the lateral meniscus.\textsuperscript{17}

The patellofemoral joint is the articulation between the patella and the femur. The patella serves to increase the moment arm of the patellar tendon. An increase in the moment arm allows for more force production from the quadriceps muscle. Furthermore, the long and thicker the patella is the longer the moment arm.\textsuperscript{18} The patella is held in place by the patellar retinaculum with the help of the lateral patellofemoral ligament (LPFL) and the medial patellofemoral ligament (MPFL), which are collectively known as the patellofemoral ligaments. While both of the patellofemoral ligaments are necessary in stabilizing the patella, the MPFL is thicker as well as stronger than the LPFL.\textsuperscript{19}

The quadriceps and hamstring muscle groups play important roles in stabilizing the patellofemoral and tibiofemoral joints. While the muscles of the quadriceps femoris group originate in different places they all insert on the tibial tuberosity. These muscles are vital in resisting lateral translation of the patella. However, a study by Hirokawa (1992) suggests that vastus intermedius played the biggest role in decreasing the risk of lateral translation. Following the vastus intermedius, the patellar tendon is the second most important structure in limiting lateral translation of the patella.\textsuperscript{20} The quadriceps muscle group puts undue stress on the ACL.\textsuperscript{21} The hamstring muscle group tends to be
more important in stabilizing the tibiofemoral joint. When the ACL is removed as a
c confounding variable, hamstring tension is inversely related to anterior translation of the
tibia.\textsuperscript{22} Hamstring contraction tends decrease force on ACL, but results in an increase in
force on the PCL.\textsuperscript{21}

**Hip** For the purpose of this study, it is necessary to focus on the hip as it pertains
to the articulation between the femur and the os coxa, or the coxofemoral joint. Four
major ligaments hold the femur in place including the pubofemoral ligament, the
ischiofemoral ligament, the illiofemoral ligament, and the ligamentum teres. The
pubofemoral ligament is compared to a sling that holds the femoral neck into the
acetabulum. This ligament is most effective in limiting external rotation while the hip is
in extension. The illiofemoral ligament also contributes to restricting external rotation in
extension, but also limits internal rotation when the hip is extended. Internal rotation is
most significantly limited by the ischiofemoral ligament.\textsuperscript{23} The ligamentum teres
functions in stabilizing the hip during internal and external rotation\textsuperscript{24,25} as well as
abduction.\textsuperscript{24}

While ligamentous structures are important to the stability of the hip, musculature
also plays a role. Specifically, the hip adductors and abductors are necessary in
stabilizing the hip.\textsuperscript{26} Adductors of the hip include the adductor brevis, adductor longus,
adductor magnus, gracilis and pectineus. The gluteus medius is assisted by the gluteus
minimus, sartorius, and tensor fascia latae in abducting the hip.

**Kinetic Chain**

In 1984, David Winter completed research dealing with the kinetic chain. He
suggested that although kinematics of the lower extremity may stay consistent, kinetics
were constantly changing. The cadence and walking pattern will appear the same, but the moments at each articulation will change. As the moments at the hip change, moments at the knee will change, and moments at the ankle will change. This is explained by the various muscles that cross two articulations, such as the rectus femoris, the biceps femoris, and the gastrocnemius. These biarticulate muscles have opposite functions at each joint, so when shortened they cause contradictory motions at the neighboring joints.

**Sprinting/Running Biomechanics**

All of the articulations, ligamentous structures and muscles interact in order to allow the lower extremity to create motion.

**Kinematics** Kinematics includes the components of motion without the inclusion of external forces. The majority of the kinematics of sprinting can be described the sagittal plane. Generally speaking, the knee and hip stay in flexion while the ankle remains in dorsiflexion all in order to lower the center of gravity (COG) of the subject. However, the degrees of movement vary throughout a stride cycle.

**Hip** As the leg progresses from stance to swing phase, the hip moves from extension to flexion. Peak flexion of the knee can be found in the late or terminal swing phase. Late swing is also the phase in which the peak angular velocity of flexion, peak flexion moment, and peak flexion power occur. Twelve male athletes involved in a sprint based sport were analyzed in a study by Lee, Reid, Elliot, and Lloyd. Results showed a median peak flexion of about 80° and a peak angular velocity of flexion of about 15° per second. When the leg moves from the swing phase to the stance phase,
the hip will move from peak flexion to minimal flexion or minimal extension.\textsuperscript{28-32} Peak extension of the hip can be found in the stance phase at toe-off.\textsuperscript{32}

Although most of the motion at the hip occurs in the sagittal plane\textsuperscript{28-32} there is minimal but significant motion in the coronal plane.\textsuperscript{30-32} At initial contact of stance phase the hip is at about 8° of adduction, then abducts during propulsion to be at about 2° of adduction. During initial swing the hip moves from about 2° of adduction to about 8° of abduction. Then, at the end of terminal swing the hip is at 6° of adduction.\textsuperscript{31}

**Knee** Like the hip, the knee moves from extension into flexion as the leg progresses from stance to swing phase of the sprinting gait cycle.\textsuperscript{28-32} Peak knee flexion during sprinting is about 130-140° and is seen in the late swing phase, similarly to hip flexion.\textsuperscript{28,29} At this time peak flexion angular velocity also increase to about 17° per second.\textsuperscript{29} When stance phase is initiated the angle of flexion at the knee starts to decrease. During the absorption portion of the stance phase the knee is typically at anywhere from 14-40° flexion, and then moves into about 20-40° extension during the propulsion portion.\textsuperscript{31} There is also a possibility for minimal varus force on the knee during the stance phase.\textsuperscript{33}

**Ankle** During the act of sprinting, the ankle joint passes through plantar flexion as well as dorsiflexion in the sagittal plane.\textsuperscript{28,30-32} However, this time is limited due to the fact that the absorption phase is so short compared to that of running or walking. Furthermore, dorsiflexion is not quite as vital because it is not needed to clear the toe during sprinting due to the increased amount of hip and knee flexion.\textsuperscript{32} Although there is still dorsiflexion, the majority of sprinting is done on the toe, with the heel never actually making contact with the ground.\textsuperscript{28} The talocrural joint is in dorsiflexion during the
absorption portion of stance phase and progresses to plantarflexion at the time of propulsion. The same progression occurs from initial swing to terminal swing, with the ankle moving from dorsiflexion to plantar flexion.\textsuperscript{31} It is necessary to note that the foot may also display internal or external rotation during portions of the gait cycle. During the stance phase the foot will be in external rotation at the start of absorption. The foot will then move into internal rotation during propulsion. The swing phase of the gait cycle presents the foot in external rotation during initial swing and back into internal rotation for terminal swing.\textsuperscript{31}

\textbf{Kinetics} Kinetics involves the components of motion including the external forces acting upon them. The most significant measures of kinetics during sprinting are moments and ground reaction forces.

\textbf{Moments} Joint moments describe how mechanically advantageous the involved muscles are at that period in time. During sprinting, the most commonly noted moments at the knee and hip are those in the sagittal plane. For the hip, peak flexion moment is about 250 Nm.\textsuperscript{29} Knee flexion moment peaks during late swing phase at a value of 100 Nm.\textsuperscript{29}

\textbf{Ground Reaction Force} Ground reaction force (GRF) during the act of sprinting or running can be split into two portions; force during deceleration and force during midstance or push off.\textsuperscript{34-36} When looking at five different areas including the hindfoot, midfoot, metatarsals, great toe, and lateral toes, forces on the foot were focused on the metatarsals for the majority of time during a running task.\textsuperscript{37} After the metatarsals, force is focused the most on the great toe, followed by the midfoot, lateral toes, and the hindfoot. Scranton and McMaster (1976) found force duration for each region to be between about
48% and about 57% of stance phase. Additionally, progression of force placement during running is significantly different than that of walking. While forces during walking progress from heel to toe, forces during running tend to go from forefoot to hindfoot then back to forefoot. Furthermore, running applies more pressure on the toes and metatarsals with less time of contact for the hindfoot and midfoot. Overall vertical GRF will increase as the velocity of the run increases.

**Muscle Activation** Due to the varying ranges of motion during the act of sprinting, activation of musculature fluctuates throughout the gait cycle. Considering much of the hip motion involves moving from extension to flexion. EMG activity of the rectus femoris increases beginning in early swing. Activity of the quadriceps is vigorous in the first 80% of the stance phase, and the last 50-60% of the swing phase. At the ankle, the posterior calf is activated for the majority of the stance phase (80%) in order to prepare the leg for propulsion. However, for the last 20% of the swing phase and the first 20% of stance phase the anterior compartment muscles take over. Overall, the activity of the quadriceps group, hamstring group, anterior compartment muscle group, and posterior compartment muscle group increase from walking to running. Ounpuu and colleagues (1990) estimated that the activity of these groups increases by 172%, 86%, 56%, and 95% respectively.

**Anticipated Side-Step Cutting Biomechanics**

A side-step cut is performed by planting the contralateral foot to the direction the subject is supposed to go and using the ipsilateral foot to move in the desired direction. Common mechanisms of injury for ACL rupture include hyperextension paired with internal rotation of the knee as well as quick deceleration or acceleration that may
occur during a side-step cut. However, whether or not the cut is anticipated or unanticipated may have an effect on the moments at the knee and hip.

**Kinematics**

**Hip** Motion at the hip is notably different during a side-step cut than it is during a normal sprint/running gait cycle. Following deceleration, the subject initiates a change in momentum. During this time the hip is flexed and externally rotated until a change in direction is accomplished. The body needs to lean forward more than normal in order to change direction, which causes the hips to be more flexed than during normal running gait. At this time the hip will start to extend in order to accelerate the body. Typical motion at the hip during stance phase of running is about 5° of flexion. Stance phase during a side-step cut increases to a certain extent. Kim et al (2014) carried out a research study using a side-step cutting angle of 45°. During this cut the average amount of hip flexion among middle school soccer players was 39.7± 8.0. Angles for hip flexion were smaller for anticipated cuts than that of unanticipated cuts.

**Knee** The majority of existing literature pertaining to side-step cutting analyzes the kinematic changes at the knee. Much like the hip, the knee displays less of a change in flexion and abduction angles/moments during an anticipated side-step cut as compared to an unanticipated side-step cut. Like the stance phase of running, the knee is flexed during the stance phase of a side-step cut. Knee flexion angle was invariably larger during a side-step cut compared to a simple run task, though moment of knee flexion during the side-step cut was much larger than moments during a run task. Besier, et al (2000) found this only to be significant during a 30° side-step cut.
Additionally, the knee is at external rotation at initial toe strike and terminal stance. Both initial toe-strike and terminal stance also denote the areas of maximum external rotation of the tibia. Between initial foot strike and terminal stance the tibia enters internal rotation, which is not large enough to be classified as maximum internal rotation compared to internal rotation during the swing phase. An example of tibial rotation measures during a side-step cutting maneuver can be taken from a study completed by Cross, Gibbs, and Bryant (1989). This study involved eleven male subjects between the ages of 17 and 30. Average total tibial rotation during stance phase was 19.84±5.63°.43

_Ankle_ A side-step cut adds multiple ranges of motion at the ankle. In addition to the dorsiflexion28,30-32 and internal/external rotation31 that is seen during a running task, there may also be inversion/eversion.42 In early stance phase the ankle will be in inversion and plantar flexion.45 Valgus forces at the knee result in more internal rotation of the foot during early stance.41 The ankle continues to be in inversion during midstance, but switches to dorsiflexion. At terminal stance the ankle returns to inversion and plantar flexion.45

_Kinetics_

_Moments_

_Hip_ Moments of hip flexion were found to be smaller during anticipated side-step cutting than unanticipated side-step cutting.42 Additionally, increased knee valgus forces during initial contact result in larger angles of hip abduction and internal rotation.41
**Knee** Current research suggests that knee moments of internal rotation during initial contact of a side-step cut are four times that of external rotation during a running task. At peak push off internal rotation increases to five times that of external rotation. When the knee is subjected to a side-step cut, motion in the frontal plane is added to the analysis. Valgus forces are initiated during the weight acceptance portion of stance phase as well as the push-off portion. During these instances of a running task the knee would have varus orientation. The valgus forces applied during a 60° side-step cut have been described as two to six times the varus force applied during running.

**Ground Reaction Force** Due to the increases in valgus moments described at the knee, a side-step cut is going to cause changes to the GRF. Valgus moments will cause the lateral GRF to increase. The lateral GRF results in a lateral translation of forces on the tibia, increasing the moment arm. Consequently, the valgus forces at the knee are further exaggerated. The increase in GRF during the side-step cutting task may be a predisposing factor to injury.

**Biomechanics With Cleated Shoes**

Certain research suggests that fixation of the foot is a plausible mechanism of injury for knee injuries during cleat sports. Release coefficients exist between cleated shoes and playing surfaces that can be deemed safe or unsafe. In a study examining high school football injuries in Philadelphia it was suggested that cleats with a release coefficient of 0.49 or greater are unsafe and should not be used. Additionally, in the NFL in 1997 just 6.6% of noncontact ACL injuries occurred in court shoes while the remaining 93.4% occurred in cleated shoes, turf shoes, or molded cleats.
There are various cleat designs that make it difficult to generalize biomechanical changes to cleats in general. Playing surface may have an additional effect on these results. There were notable differences between four different shoes when analyzing anterior translation of the tibia and torsional rotation. Heidt et al (1996) examined a court shoe, a turf cleat, a molded cleat and a traditional cleat. Anterior translation on grass was greatest for the traditional cleat, followed by the molded cleat, turf shoe and finally the court shoe, with mean values for the traditional cleat being 440.17±319.90 greater than the court shoe. The same sequence held true in comparing torsional rotation on grass. However, it is necessary to note that this study was completed on testing apparatus and did not involve dynamic exercise.

Some research has looked at biomechanics of the knee and ankle while wearing cleats and completing dynamic exercises. It is suggested that cleats may result in larger knee flexion moments during 180° cuts. Additionally, during weight acceptance the knee was subject to large changes in joint moments from extension to extreme flexion. Maximum GRF is seen during weight acceptance resulting in an increase in peak knee negative extensor moment. Compared to a running shoe, the studded cleats had smaller loading response peak knee adduction moments than running shoes during a single-leg land cut and smaller loading response peak knee adduction moments during 180° cuts. Plantar flexion moments did not differ between running shoes and natural turf studs, but was smaller in synthetic turf studs than running shoes.

Changes at the knee also occur during 30 and 60° side-step cuts. Peak mean and mean internal tibial moments increased during both cuts compared to moments during running when wearing a studded soccer boot. Like side-step cuts in running shoes,
peak mean and mean valgus moments increased during side-step cutting, mostly between 27 and 40% of stance phase. Anterior joint forces increased, but only during a 60° cut.

**Ankle Tape/Brace Effects on Biomechanics**

A plethora of researchers have examined ankle tape jobs/bracing as an intervention, and its effects on knee biomechanics. Due to the fact that these interventions are similar to spat tape jobs, they may have similar effects.

**Ankle Tape** An ankle tape job typically involves some form of anchor strips, stirrups, heel locks and figure eights in order to limit ROM of the ankle. Although these techniques are focused at the ankle they have additional effects up the kinetic chain.

One factor that contributes to the increased risk of ACL injury is an increase in peak varus moment and varus impulse as it pertains to the knee. Ankle taping has been suggested to decrease these values during an anticipated side-step cut. Only when the cut was unanticipated did the varus moment and varus impulse seem to increase. Additionally, ankle taping decreased internal rotation moment and peak varus moment of the knee during both a side-step cut and running. Stoffel et al found that these values decreased by 18% and 5% in male Australian football players, respectively. Although values were not determined to be statistically significant, peak valgus moment of the knee during a side-step maneuver increased as a result of a conventional ankle tape job.

Ankle taping does have effects at the ankle that may be desirable to those who experience chronic ankle instability. The intervention decreased pronation and supination during gait analysis and a side-step cut. Specifically, at touchdown of stance phase, supination tended to decrease. Pronation will also increase during stance phase, which
may be contributed to a shift in center of pressure.\textsuperscript{53} During push off of gait analysis center of pressure usually falls under the great toe. However, when the ankle is taped the center of pressure tends to move laterally underneath the second toe.\textsuperscript{53} In the frontal plane, dorsiflexion moment and plantar flexion moment increased during a side-step cut with ankle taping as an intervention.\textsuperscript{52} Peak eversion and inversion went down during running, but only eversion decreased during a preplanned side-step cut.\textsuperscript{52}

**Bracing** There is little research to suggest that prophylactic ankle bracing may change forces on the knee during side-step cutting and running tasks. More thorough studies have looked at the relationship between bracing and ankle mechanics during side-step cutting.\textsuperscript{45,53-55}

At the knee, bracing had minimal effects on biomechanics. During a 90° cut wearing and Active Ankle© brace, medial and lateral forces on the knee were both significantly smaller than those of a control group.\textsuperscript{54} However, there was no statistically significant difference in knee ROM. Similarly, anterior and posterior translation of the tibia on the femur was not different when compared to a control group.\textsuperscript{54}

During gait analysis using a semi-rigid, pronation does not differ from an unbraced ankle.\textsuperscript{53} Pronation does tend to increase when using a cloth brace.\textsuperscript{53} Like ankle taping, bracing results in decreased supination of the ankle at touchdown and a lateral shift in center of pressure.\textsuperscript{53} In the frontal plane, plantar flexion decreases, but only during early stance.\textsuperscript{45} Inversion decreases through all portions of stance phase as compared to unbraced ankles during gait analysis \textsuperscript{53} as well as a 45° cut.\textsuperscript{45} Much like ankle taping, ankle bracing causes the center of pressure to shift laterally \textsuperscript{53} which results in a lower peak medial ground reaction force.\textsuperscript{55}
Although there is speculation that lace up ankle braces, this may not be the case.\textsuperscript{56} McGuine et al. selected a population of high school football players and compared injury rates with lace up braces to a control group. Braces did not cause significant changes in injury at the knee or hip, but likelihood of knee injuries did increase (15.8\% to 16.3\%).\textsuperscript{56} Additionally, the incidence of acute ankle injuries did decrease for the braced group.\textsuperscript{56} The same group of researchers found similar results pertaining to acute ankle injury and acute knee injury in high school basketball player. This study did report an increase in overall lower extremity injuries as compared to the control group.\textsuperscript{57} However, such little changes may have occurred because external support from lace up ankle braces may not be sufficient in limiting motion to cause injury at the knee as compared to hard shell braces.\textsuperscript{56,57}

**Spat Tape**

Spat tape jobs are used by athletes in order to minimize the movement at the ankle.\textsuperscript{58} This intervention involves figure eights around the midfoot, leaving the heel and toes uncovered. It functions in limiting the amount of stress on anterior and posterior ligaments of the ankle. Spat tape jobs can be altered and specified for each athlete and his specific injury.\textsuperscript{58}

Current research regarding the use of spat tape jobs is controversial. Research involving spat tape was initially completed because studies had shown that conventional under-the-shoe tape lost its tensile strength after short bouts of exercise.\textsuperscript{59} One researcher hypothesized that the moment arm created with a spat tape job as it relates to the subtalar joint increases mechanical resistance to inversion.\textsuperscript{60} Additionally, the use of more tape may also have an effect on range of motion.\textsuperscript{60} However, issues arise when determining
the amount of injuries that have occurred as a result of this intervention. Scranton et al (1997) determined that 38% of noncontact injuries in the NFL in 1997 occurred during the use of spat tape.3

Due to the fact that there is no universal protocol for completing a spat tape job, two researchers have completed studies using different protocols.59-61

**Suggested Effects** Research involving spat tape has looked at dependent variables including static plantar flexion,59 static inversion,59,60 perceived comfort, perceived restriction,59 anterior tibial translation, tibial rotation48 and GRF.62

When examining plantar flexion and inversion, spat tape jobs limited plantar flexion an additional 4-5° as compared to a conventional tape job. These measures held true at 40 and 60 minutes into exercise. Baseline measures for conventional ankle taping and spat taping were similar, but following exercise, plantar flexion values for the conventional ankle tape were not significantly different than baseline values, suggesting that spat tape holds tension longer than conventional taping.59

Similarly, inversion was limited by 3° even as short as 20 minutes into exercise and continued to limit motion at 40 and 60 minutes.59 In a comparable study, Pederson et al. also suggest that inversion is limited further by a spat tape job than a conventional ankle tape job.60 These researchers found that spat tape decreased inversion by 39% prior to exercise which involved rugby specific tasks. This number decreased to 33% following exercise. Although ankle tape also decreased inversion, it was on a smaller scale (35% and 20%, respectively). Unfortunately, the differences in the two interventions were not found to be statistically significant.60 Research has also suggested that a combination of
both spat tape and conventional ankle tape was even more effective in limiting inversion\textsuperscript{60,61} as well as eversion, plantar flexion and dorsiflexion.\textsuperscript{61}

Although an inadequate amount of research has been conducted examining performance based outcome measures, it has been suggested that spatting has a limited effect. Neither a spat tape job nor a combination spat tape job and conventional ankle tape altered peak ground reaction force during a jump landing task.\textsuperscript{62} Although anecdotal evidence may suggest that spatting would increase risk of injury up the kinetic chain this may not be the case. On wet and dry surfaces, Heidt et al found that spat tape jobs resulted in a reduction of anterior translation and rotation at the knee.\textsuperscript{48} As previously mentioned, these motions are common mechanisms of injury for knee pathology.\textsuperscript{11,39,40,63}

There were also no discrepancies among heart rate and time trial for a maximal sprint between conventional taping, bracing, and a spatting/conventional tape combination.\textsuperscript{61} Although conventional ankle tape has been suggested to be more comfortable,\textsuperscript{59} athletes do not perceive it to be more restrictive or protective.\textsuperscript{59,61}

**Epidemiology**

By sport, knee injuries were most frequent in volleyball players, followed by soccer players, and football players.\textsuperscript{64} Football players are most likely to suffer from an injury with girls soccer and boys soccer teams following behind.\textsuperscript{64} Injury rates for these teams were found by Darrow et al. to be 5.93, 5.16 and 3.93 respectively.

The occurrence of ankle ligament injuries in the United States may be sufficient evidence that spat tape would be beneficial in high school athletes. Between the years of 2005 and 2011 the National High School Sports Related Injury Surveillance System examined data on ankle ligamentous injury. For every 10,000 exposures (1 athlete
participating in 1 practice or game) there were 3.65 ankle injuries. Of these injuries, football player were most likely to suffer, followed by girls soccer and boys soccer. Additionally, ankle sprains were experienced during, boys and girls volleyball, boys and girls basketball, wrestling, baseball, softball, girls field hockey, girls gymnastics, boys ice hockey, and boys and girls lacrosse. Overall relative risk for ankle ligaments injuries were 3.13.

Injuries across genders may depend significantly on the sport being examined. Similar, in populations of lacrosse and basketball players, girls were more likely than boys to suffer an injury to the knee. For the ankle, female lacrosse athletes and male basketball players experienced the most issues. The majority of hip injuries were seen in girls basketball players and boys lacrosse players.

In collegiate athletes, lower extremity injuries are the most common, accounting for 53.8% and 53.7% of injuries in games and practices respectively. Ankle ligament sprains were reported in the highest frequency in collegiate athletes from 1988-2004, with 27,117 incidences. These injuries were most commonly seen in football (9,929), men’s basketball (3,205), women’s basketball (2,446) men’s soccer (2,231), women’s soccer (1,876) and volleyball (1,649). It is important to note that teams with a men’s and women’s side showed higher injury rates on the men’s side. Similarly, ACL injury was the highest in football (2,159), men’s basketball (167), women’s basketball (498) men’s soccer (168), and women’s soccer (411) with 4,800 total injuries accounted for during the same time period.
Etiology

Knee Some of the most common mechanisms of injury for the tibiofemoral joint involve mal-alignments and extreme changes in motion. Specifically, ligamentous injury can occur during quick changes in direction, jump landings and sudden deceleration. Most commonly, the ACL loading is increased due to a contribution from knee valgus, varus (knee abduction loads) and internal moments when shearing forces are applied anteriorly to the proximal end of the tibia. These anterior forces are associated with a decrease in knee flexion angles.

As far as jump landing, landing on one or both legs can be a mechanism of injury for the knee. The specific mechanism would be valgus orientation of the knee with either internal rotation or external rotation and the knee at nearly terminal extension at landing. All of the previously mentioned mechanisms are noncontact mechanisms, which have been suggested to be the most common.

Hip Although current research suggests that ankle and knee injuries are the most common, hip injuries are seen on occasion. Like knee injuries, these can be caused by abnormal ranges of motion. There is a relationship between the sum of internal and external rotation as well as hip abduction and injury to the hip, groin, and hamstring. When looking at professional baseball players, a decrease in the total hip arc, hip related injuries were more common. The same researchers suggest that this decrease in ROM acts similar to GIRD at the shoulder, resulting in microtrauma to the supporting structures. An additional risk factor for hip injury is strength imbalances between the abductors and adductors. Lastly, a combination of high body mass index and small diameter of the femur can also be a risk factor for hip injury.
For the purpose of this study, etiology of hip injury is important to note, not necessarily because of the incidence of hip injury, but because of the effects it has on knee injury. As discussed by Dr. Winter, changes in one articulation result in changes up and down the kinetic chain.\textsuperscript{2} During a side-step cut, the mixture of decreased trunk rotation in the direction a subject plans to go and an increase in hip adduction moment results in variability in knee varus moment.\textsuperscript{77} Similarly, changes in knee internal and external moments were explained by trunk flexion and hip internal rotation moment.\textsuperscript{77}
Appendix C

Additional Methods

Executive Summary

Project Description
Musculoskeletal Health and Movement Sciences Laboratory
University of Toledo

Project Title: Effect of External Ankle Tape on Lower Extremity Kinetics and Kinematics in Young Adult Males
Project Supervisor: Neal Glaviano, PhD, AT, ATC (Assistant Professor of Athletic Training)
Research Team: Chandler Moore, AT, ATC (masters student in athletic training)
Charles Armstrong, PhD (committee member)
Christopher Ingersoll, PhD, AT, ATC, FNATA, FASAHP (committee member)

Purpose: To determine differences in knee and hip biomechanics resulting from the use of external ankle tape during an anticipated side-step cutting task and a straight sprint task.

Subjects: 16 healthy young adult males

Inclusion Criteria: Healthy, males between the age of 18 and 30, experience in cutting sport such as soccer, football, volleyball, basketball, lacrosse, hockey, etc.

Exclusion Criteria: Any lower extremity injury requiring surgery
Any lower extremity injury still causing pain or dysfunction
Any vestibular or balance condition

Study Design: Crossover (all subjects receive all treatments)

Independent Variable:
External Ankle Tape Condition
1) With external ankle tape
2) Without external ankle tape

Dependent Variables:
1) Kinematic values
i. Frontal plane
   a. Time series analysis
ii. Sagittal plane
   a. Time series analysis
iii. Transverse plane
   a. Time series analysis

2) Kinetic values
i. Frontal plane
   a. Time series analysis
ii. Sagittal plane
   a. Time series analysis
iii. Transverse plane
   a. Time series analysis
iv. Ground Reaction Force
   a. Vertical ground reaction force
   b. Lateral ground reaction force

**Procedures:**

1) Recruit healthy young adult males
2) Complete informed consent
3) Demographics and data collection form
4) Shoe fitting (Asics)
5) Marker placement
6) Static and dynamic trials
7) 3-5 practice trials
8) 10 trials randomized and counterbalanced by activity
   i. Straight sprint
   ii. Sidestep cut
9) Repeat step 8 with/without external ankle tape depending on randomization
10) Completion of collection

**IRB Protocol: UT SBE #201478**

**Statistical Analysis:** For each dependent variable, a time series analysis was completed to detect differences. Ninety percent confidence intervals were utilized at an A priori alpha level ≤0.01.

**Research Hypotheses:**

There will be an increase in hip flexion angle, hip moment in the sagittal plane, increase in hip internal rotation angle, an increase in hip transverse plane moment, increase in knee flexion angle, knee moment in the sagittal plane, an increase in knee abduction angle, an increase in knee moment in the frontal plane, an increase in knee
internal rotation angle, an increase in knee moment in the transverse plane, as well as a decrease in ankle angle values in all planes, a decrease in ankle moment in all planes and an increase in mediolateral ground reaction forces during both tasks.
ADULT RESEARCH SUBJECT INFORMATION AND CONSENT FORM AND
AUTHORIZATION FOR USE AND DISCLOSURE OF PROTECTED HEALTH INFORMATION

THE EFFECTS OF EXTERNAL ANKLE TAPE ON HIP AND KNEE BIOMECHANICS DURING
A SIDE-STEP CUT IN COLLEGE AGE MALES

Principal Investigator: Neal Glaviano, PhD, AT, ATC
Other Staff (identified by role): Chandler Moore, ATC (student-investigator)
Contact Phone number(s): (419) 530-4501

What you should know about this research study:

- We give you this consent/authorization form so that you may read about the purpose, risks, and benefits of this research study. All information in this form will be communicated to you verbally by the research staff as well.
- Routine clinical care is based upon the best-known treatment and is provided with the main goal of helping the individual patient. The main goal of research studies is to gain knowledge that may help future patients.
- We cannot promise that this research will benefit you. Just like routine care, this research can have side effects that can be serious or minor.
- You have the right to refuse to take part in this research, or agree to take part now and change your mind later.
- If you decide to take part in this research or not, or if you decide to take part now but change your mind later, your decision will not affect your routine care.
- Please review this form carefully. Ask any questions before you make a decision about whether or not you want to take part in this research. If you decide to take part in this research, you may ask any additional questions at any time.
- Your participation in this research is voluntary.

PURPOSE (WHY THIS RESEARCH IS BEING DONE)
You are being asked to take part in a research study examining how your ankle, knee, and hip move during running and an athletic task of running forward and changing directions to your right while planting on your left foot, this is known as a side-step cut. The purpose of the study is to determine the difference in how your ankle and knee move during running and a side-step cut with and without tape over your shoe (external ankle tape).
You were selected as someone who may want to take part in this study because you are a college male with experience in football, soccer, basketball, volleyball, tennis, or lacrosse. This research study will be conducted in the Musculoskeletal Health and Movement Science Laboratory in the Health Science and Human Service Building at the University of Toledo Main Campus. We will be enrolling 40 subjects between the age of 18-30 years.

**DESCRIPTION OF THE RESEARCH PROCEDURES AND DURATION OF YOUR INVOLVEMENT**

If you decide to take part in this study, you will be asked to report to the Musculoskeletal Health and Movement Sciences Laboratory at the University of Toledo on a single occasion. Subjects will perform a running task and a side-step cutting task, similar to what you would do if you were playing basketball. Both tasks will be completed with and without external ankle tape. This entire testing session will take approximately 2.5 hours.

**Eligibility Screening**

Before you can officially enroll in this study, you will be asked a series of questions to determine your eligibility. These questions are similar to ones you would be asked in a health history screening at your doctor's office. You will also have your height and weight measured as you would at your doctor's office.

**Surveys**

You will be asked to complete three brief questionnaires to provide the researchers with information regarding how well your knee is functioning and in what types of activities you are currently able to participate. These will take approximately 10 minutes to complete.

**Prior to Warm-up**

Padding will be placed in front of the wall as a precautionary safety for the subjects. Upon arrival, you will be randomly assigned to one of two groups to determine whether you complete the tasks with or without external ankle tape first. Lab standardized socks and shoes will be provided for you during testing. Ankle, knee and hip movement will be recorded for both tasks using reflective markers placed on the body using adhesive squares. Thigh and shank covers holding multiple reflective markers will be attached using elastic tape. 3-D motion capture software will be used to collect and analyze the data. Video files will be saved on a password protected computer.

**Warm-Up**

You will be allowed up to 10 minutes to warm up your muscles by walking on a treadmill.

**Athletic Tasks**

The first task will be the running task in which you will take approximately a four-step-approach, strike a target on the floor with the appropriate limb, and continue running forward. For the side-step cutting task, you will take approximately a four-step approach, strike a target on the floor with the appropriate limb, and cut at a 45° angle. The side-step cutting tasks involves planting on the left foot and stepping to the right with the right foot. You will be given as many practice trials as needed to familiarize themselves with the tasks. You will be asked to perform up to 5 trials of each task in two conditions, with external ankle tape and without external ankle tape. After ten successful trials have been recorded for both conditions the study will be completed. All tasks will be anticipated tasks, meaning you will know which direction you are cutting. You will be offered as much rest as you need between trials. This task will take approximately 40 minutes to perform.
RISKS AND DISCOMFORTS YOU MAY EXPERIENCE IF YOU TAKE PART IN THIS RESEARCH

Likely Risks
- Muscle soreness or knee discomfort. You will be given adequate warm-up.

Unlikely Risks
- Injury to your knee. This risk is unlikely if you have been cleared for full activity.
- Skin irritation due to application of reflective markers with adhesive tape.
- Breach of confidentiality. This risk is unlikely as hard-copy information will be kept in locked filing cabinets and electronic information will be kept on password protected computers. Both the filing cabinet and the computer are kept in a key code protected lab.

POSSIBLE BENEFIT TO YOU IF YOU DECIDE TO TAKE PART IN THIS RESEARCH
There are no direct benefits to you for participating in this research study. This study is designed for the investigators to learn more about biomechanics in a male population with external ankle tape during sport specific tasks.

COST TO YOU FOR TAKING PART IN THIS STUDY
You will be asked to pay for all costs associated with travel to and from the University of Toledo’s main campus as a result of participating in this study.

PAYMENT OR OTHER COMPENSATION TO YOU FOR TAKING PART IN THIS RESEARCH
If you decide to take part in this research you will not receive any financial compensation for participating.

ALTERNATIVE(S) TO TAKING PART IN THIS RESEARCH
The only alternative to taking part in this research is not to participate. Your care through the University of Toledo Medical Center will not be affected should you decline participation.

CONFIDENTIALITY - (USE AND DISCLOSURE OF YOUR PROTECTED HEALTH INFORMATION)
By agreeing to take part in this research study, you give to The University of Toledo (UT), the Principal Investigator and all personnel associated with this research study your permission to use or disclose health information that can be identified with you that we obtain in connection with this study. We will use this information to for the purpose of conducting the research study as described in the research consent/authorization form.

Under some circumstances, the Institutional Review Board, or the Research and Sponsored Programs of the University of Toledo may review your information for compliance audits. We may also disclose your protected health information when required by law, such as in response to judicial orders.

The University of Toledo is required by law to protect the privacy of your health information, and to use or disclose the information we obtain about you in connection with this research study only as authorized by you in this form. There is a possibility that the information we disclose may be re-disclosed by the persons we give it to, and no longer protected. However, we will encourage any person who receives your information from us to continue to protect and not re-disclose the information.

The information that we will use or disclose includes demographic information, medical history, and biomechanical information. Biomechanical information will include measurements of joint segments and joint angles. These measurements will be taken from video files and analyzed in 3-D Motion Analysis. 3-D models will be created for each subject at which time the subject will be un-identifiable. No one except the researchers will have access to identifiable information on each subject. There is a minimal risk for a breach in confidentiality. However, biomechanical data will be kept on a password protected computer in a key code protected lab so the risk is minimal.
Your permission for us to use or disclose your protected health information as described in this section is voluntary. However, you will not be allowed to participate in the research study unless you give us your permission to use or disclose your protected health information by signing this document.

You have the right to revoke (cancel) the permission you have given to us to use or disclose your protected health information at any time by giving written notice to:

Neal Glaviano, PhD, AT, ATC at 419-530-4501

However, a cancellation will not apply if we have acted with your permission, for example, information that already has been used or disclosed prior to the cancellation. Also, a cancellation will not prevent us from continuing to use and disclose information that was obtained prior to the cancellation as necessary to maintain the integrity of the research study.

Except as noted in the above paragraph, your permission for us to use and disclose your protected health information will stop at the end of the research study.

A more complete statement of University of Toledo’s Privacy Practices is set forth in its Joint Notice of Privacy Practices. If you have not already received this Notice, a member of the research team will provide this to you. If you have any further questions concerning privacy, you may contact the University of Toledo’s Privacy Officer at 419-383-6033.

**IN THE EVENT OF A RESEARCH-RELATED INJURY**

In the event of injury resulting from your taking part in this study, treatment can be obtained at a healthcare facility of your choice. You should understand that the costs of such treatment will be your responsibility. Financial compensation is not available through The University of Toledo or The University of Toledo Medical Center.

By signing this form you are not giving up any of your legal rights as a research subject. In the event of an injury, contact:

Neal Glaviano, PhD, AT, ATC at 419-530-4501.

**VOLUNTARY PARTICIPATION**

Taking part in this study is voluntary. You may refuse to participate or discontinue participation at any time without penalty or a loss of benefits to which you are otherwise entitled. If you decide not to participate or to discontinue participation, your decision will not affect your future relations with the University of Toledo or The University of Toledo Medical Center.

**NEW FINDINGS**

You will be notified of new information that might change your decision to be in this study if any becomes available.

TEXT CONTINUED ON NEXT PAGE
OFFER TO ANSWER QUESTIONS
Before you sign this form, please ask any questions on any aspect of this study that is unclear to you. You may take as much time as necessary to think it over. If you have questions regarding the research at any time before, during or after the study, you may contact:

Neal Glaviano, PhD, AT, ATC at 419-530-4501

If you have questions beyond those answered by the research team or your rights as a research subject or research-related injuries, please feel free to contact the Chairperson of the University of Toledo Biomedical Institutional Review Board at 419-383-6766.

SIGNATURE SECTION (Please read carefully)

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES THAT YOU HAVE READ THE INFORMATION PROVIDED ABOVE, YOU HAVE HAD ALL YOUR QUESTIONS ANSWERED, AND YOU HAVE DECIDED TO TAKE PART IN THIS RESEARCH.

BY SIGNING THIS DOCUMENT YOU AUTHORIZE US TO USE OR DISCLOSE YOUR PROTECTED HEALTH INFORMATION AS DESCRIBED IN THIS FORM.

The date you sign this document to enroll in this study, that is, today’s date, MUST fall between the dates indicated on the approval stamp affixed to the bottom of each page. These dates indicate that this form is valid when you enroll in the study but do not reflect how long you may participate in the study. Each page of this Consent/Authorization Form is stamped to indicate the form’s validity as approved by the UT Biomedical Institutional Review Board (IRB).

Name of Subject (please print) ______________________________ Signature of Subject or Person Authorized to Consent ______________________________ Date ____________

Relationship to the Subject (Healthcare Power of Attorney authority or Legal Guardian) ______________________________ Time a.m. p.m. ____________

Name of Person Obtaining Consent (please print) ______________________________ Signature of Person Obtaining Consent ______________________________ Date ____________

Name of Witness to Consent Process (when required by ICH Guidelines) (please print) ______________________________ Signature of Witness to Consent Process (when required by ICH Guidelines) ______________________________ Date ____________

YOU WILL BE GIVEN A SIGNED COPY OF THIS FORM TO KEEP.
Demographics

• Height
• Weight
• Physical Activity
Inclusion/Exclusion Check List

Effects of External Ankle Taping on Lower Extremity Kinetics and Kinematics in Young Adult Males

Subject #: ___________ Investigator Initials: ___________
Age: ___________ Weight (in): ___________ Weight (lbs): ___________

**INCLUSION CRITERIA**

- [ ] Yes  [ ] No  Age of 18 - 30 years
- [ ] Yes  [ ] No  Healthy
- [ ] Yes  [ ] No  Male
- [ ] Yes  [ ] No  Experience in sports where you often change direction

**EXCLUSION CRITERIA**

- [ ] Yes  [ ] No  Lower extremity surgery
- [ ] Yes  [ ] No  Lower extremity injury within the past 6 weeks that still results in pain or dysfunction
- [ ] Yes  [ ] No  History of chronic ankle instability
- [ ] Yes  [ ] No  Vestibular, balance or connective tissue disorder
- [ ] Yes  [ ] No  Female

Comments: __________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

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__________________________________________________________

__________________________________________________________

__________________________________________________________

Assigned Version Date: 09/16/2016

APPROVED BY
UNIVERSITY OF TOLEDO IRB
Tegner Activity Scale

TEGNER ACTIVITY LEVEL SCALE

Please indicate in the spaces below the HIGHEST level of activity that you participated in BEFORE YOUR INJURY and the highest level you are able to participate in CURRENTLY.

BEFORE INJURY: Level________ CURRENT: Level________

| Level 10 | Competitive sports- soccer, football, rugby (national elite) |
| Level 9  | Competitive sports- soccer, football, rugby (lower divisions), ice hockey, wrestling, gymnastics, basketball |
| Level 8  | Competitive sports- racquetball or bandy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing |
| Level 7  | Competitive sports- tennis, running, motorcars speedway, handball |
|          | Recreational sports- soccer, football, rugby, bandy, ice hockey, basketball, squash, racquetball, running |
| Level 6  | Recreational sports- tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week |
| Level 5  | Work- heavy labor (construction, etc.) |
|          | Competitive sports- cycling, cross-country skiing, |
|          | Recreational sports- jogging on uneven ground at least twice weekly |
| Level 4  | Work- moderately heavy labor (e.g. truck driving, etc.) |
| Level 3  | Work- light labor (nursing, etc.) |
| Level 2  | Work- light labor |
|          | Walking on uneven ground possible, but impossible to back pack or hike |
| Level 1  | Work- sedentary (secretarial, etc.) |
| Level 0  | Sick leave or disability pension because of knee problems |


SURGICAL HISTORY

Have you had any additional surgeries to your knee other than those performed by Dr. Stone?

Yes / No

If Yes:

What procedure(s) were performed? __________________________

When was the surgery performed? __________________________

Who performed the surgery? __________________________
General Health History Form

<table>
<thead>
<tr>
<th>Height</th>
<th>Weight</th>
<th>Sex</th>
<th>Age</th>
<th>Date of Birth</th>
</tr>
</thead>
</table>

Please check below if you have had any of the following and explain checked items on line.

**General Medical**
- Allergies/Sensitivities (latex, cold, medications, etc.)
- Asthma
- Cancer
- Biomedical devices (implants, pacemaker, etc.)
- Diabetes
- Pregnant or nursing
- Recent illness (colds, flu, infection, etc.)
- Surgery
- Other: _______________________

** Neurological**
- Epilepsy/Seizures
- Anxiety disorder
- ADHD
- Diabetic neuropathy
- Multiple Sclerosis
- Parkinson disease
- Cerebral Palsy
- Vertigo
- Balance disorder
- Concussion or Traumatic brain injury
- Other: _______________________

** Cardiovascular**
- High blood pressure
- Shortness of breath
- Heart attack
- Heart disease
- Stroke
- Heart murmur
- Thrombosis or Embolism
- Marfan’s Syndrome
- Sickle cell trait
- Cardiac Arrhythmia (irregular heart beat)
- Other: _______________________

**General Orthopaedic**
- Surgery
- Previous fracture
- Sprains or Strains (ligament/muscle/tendon)
- Osteoarthritis
- Rheumatoid arthritis
- Assistive devices (crutches, braces, etc.)
- Gout
- Osteoporosis/Osteopenia
- Other: _______________________

**Other**
- Have you taken any prescription or over-the-counter medications within the last 24-hours?
  - YES  □ NO □ If yes, please list: _______________________
- Have you consumed any of the following stimulants or depressants in the last 12-hours?
  - Caffeine  □ Alcohol  □ Tobacco
  - If yes, please explain: _______________________
- Do you exercise regularly?
  - YES  □ NO  □ If yes, what type and for how long? _______________________
- Are you currently experiencing physical pain?
  - YES  □ NO  □ If yes, please indicate location, severity, and currently treatments for you pain: _______________________

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General Data Collection Form

Subject Number:

Please answer the following questions with YES or NO to the best of your knowledge.

1. Pertaining to any previous injury, are you concerned at all about completing the tasks being asked of you today?

2. Have you ever sprained your ankle?
   a. Do you ever experience a feeling of giving way or rolling over on this ankle?
   b. Do you ever experience pain associated with this injury?

3. Have you ever used external ankle tape/spat in your athletic activities?

4. Have you ever used ankle taping/ankle bracing in your athletic activities?
Cortex Hardware and Software Set-up

1. Turn on cameras (located to the right of the computer)

2. Open Cortex 5.5.0.1579
   a. Open File “Chandler Moore Cut Study” and “set as working folder”

3. All lights on force plate should be off (use calibration square for calibration)
   a. To change collection sample rate- Change Multiple of Frame Rate
      - Cameras collect 200 Frames/sec
   b. Save calibration
   c. Click “all on” and “connect to cameras”
4. Calibration of the cameras
   a. Do “update calibration”
      - Every once in a while do “floor calibration”
      - At the beginning of every day of data collection click calibrate
        for cameras
      - Click “ok to overwrite” and collect for 2 minutes with calibration
        wand
      - Check volume
      - When calibrating go through all cameras and mask any
        reflections
   b. Click center wheel and drag. Then right click to delete.
      - 3D Residual: Average approximately 0.5 and deviation
        approximately one half of average

5. Calibration of force plate
   a. Calibration square goes around force plate 1 (back corner – closet to door
      and computer

**Floor Set-up**
1. Measure 6 m from the center of force plate to where you first walk into
   Biomechanics lab
2. Mark the 6 m point with tape so the subjects know where to start
3. Mark a 45 degree angle from the right corner of force plate 2 with tape so the
   subjects know the angle to cut during the trials
4. The first gate will be placed 0.9144 m (3 ft) from the force plate
5. The second gate will be placed 6.9 m (22.6 ft) from the start line and 2.25 m (7.4
   ft) lateral to the force plate on the left and right, so the subjects will be able to run
   through the gate in the given direction
   a. Tape will be used to mark the legs of the tripod as to repeat the exact
      position for the next data collection day
6. The trials will be randomized with a total of 20
   a. 5 sprint control trials
   b. 5 sprint treatment trials
   c. 5 cut control trials
   d. 5 cut treatment trials
7. The speed to be maintained is 3.5-5.0 m/s
Cortex Data Collection Procedures (General Set-up)

1. Marker Placement
   a. Double sided tape was pre-applied to the markers prior to the subject arrival at the Exercise and Sport Injury Laboratory
   b. All areas were shaved as needed
2. To bring up saved markers click on Marker Sets “add/remove”
   a. Check the box next to “Cut Study Dynamic” and “Cut Study-NewStat”
   b. Markers will then be on the right of the screen
3. Marker Placement  
   a. 42 Reflective markers  
      i. Right inferior angle of the scapula (1)  
      ii. Sternal notch (1)  
      iii. C7 (1)  
      iv. Sacrum (1)  
      v. Acromioclavicular joints (2)  
      vi. Iliac crest, vertically in line with greater trochanter (2)  
      vii. Posterior superior iliac spine (2)  
      viii. Greater trochanter (2)  
      ix. Thigh Cluster (4, one on each thigh)  
      x. Lateral femoral condyle (2)  
      xi. Medial femoral condyle (2) (Static Trial Only)  
      xii. Shank Cluster (4, one on each thigh)  
      xiii. Medial malleoli (2) (Static Trial Only)  
      xiv. Lateral malleoli (2)  
      xv. 2nd metatarsal head (2)  
      xvi. Base of 5th metatarsal (2)  
      xvii. Calcaneus (2)
4. Each subject collection
   b. Get rid of ghost markers and reflectors in 2D by clicking the center button on the mouse and covering it with a small box to block area
   c. Name static trial- subject will do 2 of these
      - Make sure marker set is on the static set
   d. Go to recording settings and change time to 5 seconds
      - Subject will stand still for 5 seconds with arms crossed over chest
   e. For the dynamic trial take off medial markers, malleoli and femoral condyle
      - Switch marker set to dynamic
      - Do 2 trials of the dynamic pose
      - Subject will stand still for 2 seconds and when cued will begin marching in place for the next 3 seconds with arms crossed over chest
   f. Load last capture
   g. Click quick ID
      - Name each anatomical landmark on the skeleton as appears in the quick ID box
   h. Click rectify- have all markers clicked on
   i. Click linear join
   j. Click smooth
   k. Click delete Unnamed- look at timelines
      - Timelines should be solid lines with no gaps, meaning reflective markers are visible through the entire trial
      - If there are gaps, go back and complete another dynamic trial; then repeat f-k
   l. Create template
      - This template will allow the marker set to be recognized for the future trends with this subject. It will also recognize marker set up with other subjects.
m. File- Save Capture and name dynamic
n. File- Save Setup
5. Go back to Live Mode- check for correct marker set and name trials
6. Save each subject on an external hard drive- click Quick Files on top right of screen

Laptop Set-up
1. Turn on computer and log in with username and password written on computer
2. Connect to “Linksys 2504” internet
3. Click on “new folder” file
4. Go to “windows application 12”
5. This system is where the countdown will be initiated to begin each trial
   a. Turn on the right gate to light on after start of countdown so that data is collected
   b. The subject will complete a total of 20 trials
      - 5 control side-step cuts
      - 5 treatment side-step cuts
      - 5 control sprints
      - 5 treatment sprints
7. Be sure that the distance to the first gate is set to 0.9144 m and the distance to the second gate is set to 6.9 m

External Ankle Taping Procedure

1. Apply powerflex to cover ankle, back lip of shoe, and the arch of the foot

2. Apply three anchor strops proximally at the ankle
3. Apply three anchor strips distally at the arch of the foot
4. Apply 2 stirrups pulling from medial to lateral

5. Apply 4 alternating heel locks (medial, lateral, medial, lateral)

6. Apply 2 figure-8’s

7. Finish covering the tape job from proximal to distal anchor strips
Side-step Cutting Procedure
1. The subjects will have 3-5 practice trials
2. The subjects will begin at the marked start line
   a. The subject will be given a 5 second countdown and the order of “Go”
   b. The subjects will cut with their left foot on the force plate and run past the second timing gate
   c. After completion of the trial the clock will count down 30 seconds before the start of the next trial
   d. The subjects will be given more rest time if necessary

Sprinting Procedure
1. The subjects will have 3-5 practice trials
2. The subjects will begin at the marked start line
   a. The subjects will be given a 5 second countdown and the order of “Go”
   b. The subjects will approach the force plate at 3.5-5 m/s and plant with their left foot and continue on through the second timing gate
   c. After completion of the trial the clock will count down 30 seconds before the start of the next trial
   d. The subjects will be given more rest time if necessary

Cortex Processing
1. After the trials have been completed, they are must be reviewed to ensure all 38 markers stayed on and the template was recognized.
   a. If they were not, they need to be identified again as well as linear joined, smoothed, and the unnamed markers deleted
   b. Check the timeline for gaps in the markers
2. While the data is in post process, the time right before heel strike and immediately after toe off can be cut
   a. Type in the frame numbers which appear at the bottom center of the screen into the space that reads “0” for heel strike and “1000” for toe off
   b. Then click “Cut Outside”
   c. Check the timeline- you should only see the small area that was not cut

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d. Save Capture
e. Export into the C3D file

Visual 3D

1. Open Visual 3D version 5
2. Open and execute pipeline “Import_files”
   a. Import static trial
   b. Import model
   c. Insert height (m) and mass (kg)
   d. Import C3D files
   e. Check for errors

3. Save CMO as Subject X_RAW
4. Open and execute pipeline “Assign file tags”
5. Check for errors
6. Open and execute pipeline “MassxHeight”
7. Check for errors
8. Open and execute pipeline “Divide analog by 2_with moments”
9. Check for errors
10. Open and execute pipeline “filter trials_with moments”
    a. Low pass filter
    b. Force cutoff filter: 12Hz
    c. Trajectory cutoff filter: 12Hz
11. Check for errors
12. Select the recalculate option
13. Open and execute pipeline “Calculate link model based items”
14. Check for errors
15. Open and execute pipeline “Create events”
16. Check for errors
17. View each trial individual to check that events are labeled and there are no issues with the markers/models
18. Save as Subject X_PROCESSED
19. Open and execute pipeline “Identify Peak Angles and Moments”
20. Check for errors
21. Open and execute pipeline “Export Data”
22. Check for errors
23. Save
### Table 3. Speed Statistical Analyses

#### Paired Samples Statistics

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<tr>
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<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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#### Paired Samples Test

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<th>Sig. (2-tailed)</th>
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<td>Std. Error Mean</td>
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Paired T-test with alpha level set to 0.05.
Figure 6. Trunk Sprinting Kinematics with 90% Confidence Intervals

Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in NM/kg, with green and red curves representing control and experimental groups, respectively.

Figure 7. Trunk Cutting Kinematics with 90% Confidence Intervals

Frontal plane: adduction (+), abduction (-); Sagittal plane: flexion (+), extension (-); Transverse plane: internal rotation (+), external rotation (-). Values measured in NM/kg, with green and red curves representing control and experimental groups, respectively.
Appendix E

Back Matter

Recommendations for Future Research

There is not much consistency when comparing the results of this research study with previous research as well as comparing these previous studies with each other. This suggests the need for future research scrutinizing the effects of external stabilizing devices on lower extremity biomechanics while eliminating various confounding variables. Researchers should look at the relationship with external ankle tape and the environment. For example, different playing surfaces and shoe types (cleats, turf shoes, etc.) may influence the kinetics and kinematics differently. It is essential to create a more game like environment as well as possible in the laboratory setting. Unanticipated cutting tasks can be researched with the effect of fatigue and varying foot strike patterns. A gap in the research exists in regard to the effect external ankle taping may have on the kinetics and kinematics in individuals with acute ankle injury or chronic ankle instability. Overall, there is lack of research pertaining to external ankle tape which makes it difficult to make suggestions regarding the intervention.
NATA Abstract

Effects of External Ankle Taping on Lower Extremity Kinetics and Kinematics in Young Adult Males

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*University of Toledo, Toledo, OH; †University of North Carolina at Charlotte, Charlotte, NC

Context: External stabilizing devices serve to limit the range of motion of the involved joint. As the most common injury in collegiate athletes, ankle injuries are frequently supported by external ankle devices such as external ankle tape. Changes in kinetic and kinematic values at the ankle may result in changes of forces on joints up the kinetic chain due to biarticulate muscles. By using external ankle tape, clinicians may be increasing the risk of pathology in the athletic population. However, no research exists to support or refute this theory.

Objective: To compare the effect of external ankle taping on knee and hip kinematics and kinetics compared to no taping during an anticipated side-step cutting task and a straight sprint task.

Study Design: Cross-over study.

Setting: Laboratory.

Participants: 16 healthy males (Age: 23.1±2.6 years, Mass: 81.4±11.4 kg, height: 181.7±7.3 cm) with no history of lower extremity surgery, lower extremity injury in the past six months or any vestibular or balance disorders.

Intervention: Participants completed both an external taping technique and a no taping condition.

Main Outcome Measures: Three-dimensional kinematics and kinetics were collected with a 12-camera motion capture system and in-ground force plate. Participants completed 5 trials of a 6-meter sprint and 6-meter sprint with an anticipated side-step cut with or without external ankle taping. Speed of tasks were measured with custom made timing gates. Kinematic and kinetic data was reduced to 100 data points for the duration of stance phase for each task. Group means and associated 90% confidence intervals were plotted, with significance being identified when the confidence intervals did not overlap for three or more consecutive data points.

Results: No differences in speed were identified between the two tasks across the sprinting or anticipated side-step cutting task. No significant differences were found in kinetics or kinematics at the ankle, knee or hip in all three planes during a side-step cutting or a sprinting task.

Conclusion: External ankle tape did not have a significant effect on the kinetics or kinematics in healthy adult males during a sprinting or anticipated side-step cutting task. However, the basis of the study was dependent on the assumption that ankle kinematics and kinetics would be changed. A different task may be necessary to elicit these changes at both the ankle, knee, and hip. Future research should evaluate potential influences of external taping on lower extremity function in female or pathological participants.
Appendix F

Bibliography


