A Thesis

entitled

Effects of the Fibular Repositioning Taping on Lower Extremity Biomechanics during Gait in Active Adults with Chronic Ankle Instability

by

John M. McCleve IV

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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The University of Toledo

May 2017
An Abstract of

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Objective: To determine if application of fibular reposition tape (FRT) has any effect on ankle, knee, or hip kinematic, kinetics as well as vertical ground reaction forces (vGRFs) during gait in individuals with chronic ankle instability (CAI). Design: Cross over repeated measures laboratory study. Subjects: Twenty active individuals with bilateral CAI (age = 21.5 ± 4.1 years, height = 170 ± 7.5 cm, mass = 81.8 ± 22 kg). Measurements: Time series curve analysis were used for group comparisons. Groups included FRT, Sham FRT, and no tape. Measurements included ankle, knee, and hip kinematics and kinetics in the sagittal, frontal, and transverse planes throughout the entire gait cycle as well as vGRFs during the stance phase. Results: There were no significant differences when comparing the no tape and sham FRT groups for all variables across the entire gait cycle. Additionally, there were no significant results when comparing the sham FRT and FRT groups for all variables across the entire gait cycle. Conclusion: Application of FRT did not have any effect on ankle, knee, or hip kinematics or kinetics across the entire gait cycle as well as vGRFs during the stance phase in individuals with
CAI. **Key Words:** Chronic Ankle Instability (CAI), Fibular Reposition Taping (FRT), Gait, Ankle sprain, and Positional Fault.
Acknowledgements

I want to thank my committee members Dr. Christopher Ingersoll and Dr. Charles Armstrong for their help throughout this process. Also, I want to thank Dr. Luke Donovan for assisting me in getting this study started as well as for his help throughout the rest of the process. I want to specially thank Dr. Neal Glaviano for his guidance, patients, and time spent with Caroline and me, serving as our third party clinician. I value my time with Neal as he showed me how fun research can be and gave me a one of a kind research experience. With that said, I also want to thank Caroline Fitch for making our time in the lab unforgettable. I never thought I could spend so much time with someone and never get sick of them. Additionally, I want to thank my parents James and Gara Wiseman, my sister Jaden Wiseman, my roommates Luke Kervin and Taylor Frendt, my best friend Nathan Elliott, and the rest of my friends for their continuous love and support. Finally, I want to thank my loving and supportive girlfriend Marissa Pulsipher for her continuous words of encouragement and for always believing in me.
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<tr>
<td>AE</td>
<td>Athletic Exposures</td>
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<tr>
<td>ASIS</td>
<td>Anterior Superior Iliac Spine</td>
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<tr>
<td>ATC</td>
<td>Certified Athletic Trainer</td>
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<td>ATFL</td>
<td>Anterior Talofibular Ligament</td>
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<td>CAI</td>
<td>Chronic Ankle Instability</td>
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<td>CI</td>
<td>Confidence Intervals</td>
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<td>FAAM</td>
<td>Foot and Ankle Ability Measure</td>
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<td>FP</td>
<td>Functional Performance</td>
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<td>FRT</td>
<td>Fibular Reposition Taping</td>
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<td>HS</td>
<td>Heel Strike</td>
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<tr>
<td>IdFAI</td>
<td>Identification of Functional Ankle Instability</td>
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<td>ISS</td>
<td>Injury Surveillance System</td>
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<td>LAS</td>
<td>Lateral Ankle Sprain</td>
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<td>LLC</td>
<td>Lateral Ligament Complex</td>
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<tr>
<td>MAI</td>
<td>Mechanical Ankle Instability</td>
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<tr>
<td>USD</td>
<td>United States Dollars</td>
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<td>vGRFs</td>
<td>Vertical Ground Reaction Force</td>
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Chapter One

Manuscript

Introduction

The lateral ankle sprain (LAS) is the most common musculoskeletal lower extremity injury to occur in individuals who are physically active.\(^1\) Between the 2009-2010 and 2014-2015 school years, a total of 2,429 lateral ligament complex (LLC) sprains occurred across 25 National Collegiate Athletic Association (NCAA) sports resulting in an overall rate of 4.95 per 10,000 athletic exposures (AE).\(^2\) Injury data collected by the NCAA Injury Surveillance System (ISS) across 15 sports for the past 27 years revealed that ankle ligament sprains were responsible for 15% of all injuries with a reported overall incidence rate of 0.83 sprains per 1,000 AE.\(^3\) Between 2007 and 2011, annual costs in the treatment of LAS totaled 152 million United States Dollars (USD) with the majority of the costs designated to physician visits costing approximately 124 million USD.\(^4\) It’s evident that LAS occur frequently resulting in inflated healthcare costs.

The most frequent mechanism for an inversion ankle sprain consists of hyperinversion and hyperplantarflexion.\(^5,6\) After an initial ankle sprain, one’s chance of a recurrent ankle sprain significantly increases.\(^7\) Frequently, residual symptoms, self-reported disability,\(^8\) and recurrent injury\(^9\) follow after an initial ankle sprain. Together these symptoms have been used to describe the pathology known as chronic ankle instability (CAI).\(^10\) Chronic ankle instability is defined as the incidence of repetitive short periods of instability, and/or repetitive ankle sprains.\(^10\) Chronic ankle instability consists of mechanical as well as functional deficiencies. Mechanical factors contributing to CAI...
include alterations in joint structures, ligamentous laxity, arthrokinematic restrictions, structural impingement, and degenerative changes.\textsuperscript{10} Functional factors contributing to CAI include insufficient proprioception, poor neuromuscular and postural control, as well as a decrease in strength.\textsuperscript{10} Those with CAI tend to experience or suffer from a combination of these factors and together they contribute to CAI.\textsuperscript{11,12}

As already alluded, mechanical ankle instability (MAI) may result in one or more of the following: irregular joint mechanics involving joint hypermobility, joint hypomobility, ligamentous laxity,\textsuperscript{13} irregular joint position and articulations, and impaired arthrokinematics.\textsuperscript{10} After an inversion ankle sprain an anterior positional fault of the distal fibula may occur.\textsuperscript{14,15} This involves the distal fibula translating forward on the talus due to the orientation of the anterior talofibular ligament (ATF) and the anterior tension it places on the distal fibula during the plantarflexion and inversion mechanism.\textsuperscript{14} An anteriorly fault creates a bony block and malalignment in the talocrural joint creating difficulty in achieving full dorsiflexion and eversion. Inability to reach these positions will contribute to irregular gait biomechanics as well as predispose individuals with CAI to additional LASs.

During gait, individuals with CAI often experience the feeling of giving away in which occasional excessive rearfoot inversion occurs uncontrollably without experiencing an acute LAS.\textsuperscript{16} It has been determined that altered gait biomechanics exist in individuals with CAI increasing their risk to repetitive LAS leading to the onset of pathologies such as ligamentous post-traumatic ankle osteoarthritis.\textsuperscript{17} These same individuals display greater ankle inversion at pre heel strike (HS), during HS, post HS, as well as throughout the majority of the gait cycle when compared to healthy
counterparts. This means that for every step an individual with CAI takes, they are at a predisposed risk of suffering concurrent LASs due to their inability to maintain proper eversion and correct joint positioning. An anterior fault of the distal fibula may be a major contributing factor to this deficit causing more inversion and plantarflexion to occur throughout the gait cycle.

Prophylactic ankle tape and bracing has shown to reduce the occurrence of LAS. Taping and bracing have also shown to enhance cutaneous receptors while improving proprioception. Interestingly, it was determined that laced-up ankle braces do not reduce the severity of injury after a LAS. However, ankle braces did significantly reduce the rate of LAS in both high school football and basketball athletes.

Application of external ankle support has yet to show a reduction in the severity of injury suggesting that similar mechanical tissue damage occurs in both supported and non-supported injured ankles. This may be because forces undergone in the ankle during an inversion ankle sprain are too significant for any external support to prevent. Again, previous research has shown a significant reduction in the rate of LAS with external support. Therefore, the benefit of external ankle support may only be providing functional benefits by causing an enhanced sensory feedback mechanism, improving one’s ability to evert their ankle while avoiding pathological positions.

If superficial contact of external ankle support around the ankle provides functional benefits and lacks mechanical restrictions, maybe a simplified taping intervention such as the fibular repositioning taping (FRT) could provide similar functional benefits. For individuals with CAI, regular ankle tape has shown to improve
ankle positioning by altering frontal and sagittal-plane kinematics during gait.\textsuperscript{26,27} It’s evident that external ankle support has positive effects on ankle kinematics in individuals with CAI.

Fibular reposition taping has previously been used in individuals with CAI and is believed to restore fibular alignment.\textsuperscript{14} As mentioned earlier, anterior translation of the distal fibula causes irregular joint arthrokinematics and proprioception deficiency while leading to poor neuromuscular function.\textsuperscript{10,14} Recently, the role of FRT has shown to reduce the amount of LAS in basketball players,\textsuperscript{28} improve single leg jump landing mechanics,\textsuperscript{29} increase soleus h/m ratio,\textsuperscript{30} improve postural control in professional athletes,\textsuperscript{31} and provide a perceived sense of security and confidence with dynamic postural stability and functional tasks.\textsuperscript{27,32} It appears as if FRT provides beneficial effects for those with CAI improving their postural control, jump landing mechanics, and motor neuron pool excitability all of which impairments that those with CAI may experience.\textsuperscript{33} However, clinicians do not know if FRT application will have an effect on walking mechanics which is one of the impairments on the spectrum of deficits experienced by those with CAI.\textsuperscript{33} Therefore, the purpose of this study was to evaluate if the application of FRT would have any effect on ankle, knee, and hip kinematics or kinetics in the sagittal, frontal, or transverse planes as well as vGRFs during the gait cycle in individuals with CAI.

**Methods**

**Study Design** A cross-over repeated measures laboratory study was used to compare differences in ankle, knee, and hip kinetics and kinematics in the sagittal, frontal, and transverse planes throughout the gait cycle across the following three
conditions: fibular repositioning taping (FRT), sham FRT, and no tape (control). Data collection took place in the Musculoskeletal Health and Movement Sciences (MHMS) Laboratory in the Health and Human Services Building at the University of Toledo. This study was approved by the University’s Institutional Review Board (# 0000201476).

**Participants** At least 20 active individuals with bilateral CAI (age = 21.5 ± 4.1 years, height = 170 ± 7.5 cm, mass = 81.8 ± 22 kg) were recruited from a University setting, and surrounding community. In accordance with the International Ankle Consortium, participants were included if they have had a history of more than one ankle sprain with the first sprain occurring greater than 1 year ago, self-reported ankle deficits quantified by a score of < 85% on the Foot and Ankle Ability Measure (FAAM) Sport scale, and a score ≥ 11 on the Identification of Functional Ankle Instability (IdFAI).\(^{34,35}\) Participants also had to be deemed recreationally active by scoring a ≥ 24 on the Godin Leisure Time Exercise questionnaire.\(^{26}\) Participants were excluded if they had a history of an ankle fracture, history of a lower extremity surgery, acute ankle sprain within six weeks prior to data collection,\(^{34}\) a vestibular disorder, or any other illness or injury that has been shown to alter gait.

**Instrumentation** Sagittal, frontal, and transverse joint kinematics and kinetics of the ankle, knee, and hip were measured using the TrackSTAR electromagnetic motion analysis system (Ascension Technologies, Inc., Burlington, Vermont). The MotionMonitor software (Version 8, Innovative Sports Training, Inc., Chicago, Illinois) was used to control the TrackSTAR motion analysis system at a sampling rate of 144 Hz. A non-conductive wooden force plate (Bertec Corporation, Columbus, Ohio) was embedded in an elevated walk-way and sampled at a rate of 1440 Hz. Synchronized with
the electromagnetic tracking device, the force plate was used to collect vertical ground reaction forces (vGRFs) as well as to identify initial contact during the stance phase.\textsuperscript{36}

**Procedures** Participants signed the inform consent and completed a generic health questionnaire as well as the questionnaires as previously mentioned. On the FAAM Sport, participants indicated which ankle was their injured ankle. If both were considered injured, the self-perceived worst ankle was used for testing.\textsuperscript{26} A counter balanced method was used to pre-determine the sequence in which the participants received each condition. This method was used in order to account for any order effect.

Five total electromagnetic sensors were placed on the participant (4 unilateral and 1 central). Specifically, they were placed on posterior calcaneus, dorsal aspect of the first metatarsal, lateral mid-shank, lateral mid-thigh, and the 12th vertebrae of the thoracic spine. They were secured to the skin with double-sided tape, Leukotape\textregistered, and elastic wraps to minimize movement.\textsuperscript{36} Holes were cut on the heel side of the shoe in order to expose the calcaneus. This made it so that the calcaneus sensor could sit directly on the skin.\textsuperscript{37} An additional 6th sensor attached to a stylus was used to identify specific proximal and distal longitudinal and horizontal landmarks\textsuperscript{38} which included: left/right ASIS, the 5th lumbar spine vertebrae, right/left medial knee joint line, right/left lateral knee joint line, right/left medial malleolus, right/left lateral malleolus, and right/left 2nd phalanx.\textsuperscript{36} Identification of each horizontal landmark with the moveable stylus allowed for digitization of each joint.

Participants were fitted with a standardized laboratory shoe (model Gel-Contend 2, Asics, Inc, Irvine, CA). A Certified Athletic Trainer (ATC) with ten years of
experience served as a third party clinician. The ATC was in charge of participant randomization as well as condition application.

Fibular reposition taping was applied as previously described. With the participant sitting on a treatment table and socks and shoes removed, the third party clinician applied the taping. This consisted of a strip of a 1.5” of cover roll beginning over the lateral malleolus pulled posteriorly and obliquely around the calf and ending over the distal anterior tibia. This same pattern was followed with a strip of Leukotape®, however a pain free posterior glide of the distal fibula was applied. An additional strip of Leukotape® was applied in the same manner.

After sensor setup and condition application, participants were encouraged to warm-up and practice walking on the runway. Participants were instructed to walk as normal as possible, striking the wooden force plate with the tested limb, while continuously looking at the wall. To encourage this, an “x” was taped on the wall, approximately at eye level, to avoid participants from looking down while they completed the gait trials. Each participant completed practice trials to ensure their foot stroke of their test limb occurred fully on the force plate. When the ideal starting point was identified, a piece of tape was placed on the walk way to ensure consistency for all trials. Participants were also asked to walk at a self-selected comfortable speed and to maintain that speed throughout their session. The objective was to encourage normal walking for meaningful data collection.

Once participants were comfortable walking on the runway, a total of 10 separate walking trials were recorded one at a time. Following the first set of walking trials, participants had approximately 10 minutes of down time while the third party clinician
conducted the participant’s assigned second condition. Participants were given more time to practice walking if needed. When ready, another set of 10 walking trails were recorded. Proceeding, the third party clinician applied the third and final assigned condition. Afterwards, more time was given for practice if needed. Finally, 10 more walking trails were recorded under the third condition. Once data collection was complete, and the sensors were removed, participants were free to leave.

**Data Processing** Ankle, knee, and hip rotations were measured using the Euler rotation method in the X, Y, and Z planes. A low-pass 4th order, Butterworth filter at a cut-off frequency of 14.5 Hz was used to filter kinematic data. Internal joint moments (N*m/kg) were normalized to each participant’s body mass (kg) and height (cm) while vGRF (N) were normalized to each participant’s body mass.

Ten walking trials were conducted for each condition. Each full gait cycle was reduced to 100 frames so that each frame represented one percent of the gait cycle. A full gait cycle was defined as the time between initial heel strike of the tested limb on the force plate and the next heel strike of the same limb. The second initial heel strike had to be determined using the MotionMonitor software to calculate vertical foot velocity. Vertical ground reaction force was sampled at a rate of 1000 Hz and the threshold was set to 25 N in order to identify initial contact and toe off.

**Statistical Analysis** Time series curve analyses were used to represent group means with 90% confidence intervals (CI) across the entire gait cycle for the hip, knee, and ankle kinematics and kinetics in all three planes as well as vGRFs during the stance phase. Group CIs for each dependent variable were used for group comparisons. Any 3 consecutive points in which the CIs did not overlap were deemed significant.
Results

Group comparison of ankle, knee, and hip kinematics and kinetics as well as vGRFs of the sham and control groups can be found in Figures 1-3. Since there were no significant differences observed between the sham and control groups, the sham group served as the comparison to the FRT group. Group comparison of the sham and FRT groups can be found in Figures 4-6. There were no significant differences throughout the entire gait cycle in ankle, knee, or hip kinematics, kinetics as well as vGRFs when comparing the sham and FRT groups.

Discussion

The purpose of the study was to evaluate the effect of FRT on frontal, sagittal, and transverse plane kinematics and kinetics of the ankle, knee and hip during gait in individuals with CAI. Vertical ground reaction was also assessed between taping conditions. We found that the application of FRT in individuals with CAI did not cause any changes in ankle, knee, or hip kinematics or, kinetics, as well as vGRFs during the gait cycle.

To our knowledge, this was the first study to look at the effects of FRT on walking mechanics. Previously, application of FRT has demonstrated to reduce the occurrence of LAS, improve postural control and performance in functional tasks, enhance soleus h/m ratio, and provide a perceived sense of security and confidence with dynamic postural stability. However, based on our findings, the application of FRT did
not have any effect on ankle, knee, or hip kinematics, kinetics, as well as vGRFs during gait in active individuals with CAI.

Application of FRT and sham FRT has also shown to improve single leg jump landing mechanics in which participants landed in less plantar flexion and less preparatory tibialis anterior electromyography. Both tapings may have improved the sensory feedback mechanism via stimulation of cutaneous receptors. This aligns with previous studies that have reported enhanced proprioception due to tape. We did not measure joint position sense or range of motion since our main focus was on walking mechanics. Regular tape has also shown to improve ankle kinematics during gait. One reason we may not have found changes in gait biomechanics may be because FRT does not cover as much of the ankle and therefore may not be able to stimulate as many cutaneous receptors in order to enhance the feedback loop.

Previous studies have shown FRT to improve not only jump landing mechanics, but postural control and performance with functional activities. Another reason we may not have found difference may be due to the demand of the task. In those studies, participants had to perform certain tasks that they may not have been familiar with. Since walking is more likely a familiar task, the effects of FRT may not have been large enough to cause changes. With more dynamic tasks such as postural control, functional activities, and jump landing, more ankle motion at the ankle is needed in order to complete the task. With walking, not as much motion at the ankle may be needed compared to those other tasks and therefore the effects of FRT application may not have provided any changes.
An anterior positional fault of the distal fibula has been shown to exist after acute and chronic ankle sprains.\textsuperscript{15,46-48} However, there is conflicting evidence that suggests that a posterior positional fault occurs after acute ankle sprains.\textsuperscript{49-51} Differences in measuring techniques has been suggested to be the main reason for conflicting results.\textsuperscript{46} Additionally, the participants they used in each of their studies may not have been an accurate representation of individuals with CAI since a few of those studies examined individuals with acute LASs. Furthermore, it is still unknown if the positional fault is a predisposing factor to LASs or if repetitive LASs cause the positional fault to occur.\textsuperscript{46}

Clinically, FRT has been used as an intervention to provide stability to the ankle. Before use, clinicians should conduct a thorough evaluation to identify the patient’s exact impairments. Since there is no golden standard for ruling in or out a positional fault, it should be suspected based off patient history and distal fibular mobility. Since FRT has shown to improve postural control, jump landing tasks, and performance during functional tasks, it is warranted to implement FRT in similar cases. Subjectively, participants wearing FRT have consistently reported that they feel more comfortable and stable during tasks.\textsuperscript{27,32} The mere fact that FRT can provide confidence for individuals with unstable ankles is enough reason to implement FRT during exercises. Finally, if patients report lack of confidence in their ankle during walking, application of FRT may be warranted since FRT application did not show to negatively affect our participants during walking.

A major limitation in our study, as well as in past studies evaluating FRT is that we do not know if our participants in deed had a positional fault of the distal fibula.
Future research should focus on establishing a valid and reliable measure for ruling in or out a positional fault. Secondly, it has yet been established whether a positional fault occurs due to LASs or if a positional fault is a predisposing factor to LASs. Discovering the answers to these unknowns will give clinicians a greater understanding and ability to address their future patient’s exact impairments and improve outcomes sooner.

**Conclusion**

Application of FRT in individuals with CAI did not have any effect on ankle, knee, and hip kinematics, kinetics, as well as vGRFs during gait. Future research should focus on establishing a valid and reliable measure for ruling in or out a positional fault. Furthermore, future research should also determine if a positional fault occurs due to the occurrence of LASs or if the occurrence of LASs causes a positional fault.
Table 1. Demographics of Participants

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<tr>
<td>Age</td>
<td>21.5 ± 4.1</td>
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<tr>
<td>Height (cm)</td>
<td>170 ± 7.5</td>
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<tr>
<td>Weight (kg)</td>
<td>81.8 ± 22</td>
</tr>
<tr>
<td># of ankle sprains</td>
<td>7.2 ± 5.3</td>
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<tr>
<td>First Ankle Sprain (months)</td>
<td>98.4 ± 58.1</td>
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<tr>
<td>Most Recent Ankle Sprain (months)</td>
<td>10.5 ± 8.1</td>
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<td>FAAM Sport (%)</td>
<td>63.9 ± 17.6</td>
</tr>
<tr>
<td>IdFAI</td>
<td>22 ± 5.5</td>
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<tr>
<td>Godin Leisure</td>
<td>67.3 ± 33.5</td>
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n=number of subjects, cm=centimeters, kg=kilograms, FAAM=Foot and Ankle Ability Measure, IdFAI=identification of functional ankle instability
Figure 1. Kinematic data for the ankle, knee, and hip in all three planes comparing sham vs control groups across the entire gait cycle.

Figure 2. Kinetic data (Nm/kg) of the ankle, knee, and hip in all three planes comparing sham and control groups across the entire gait cycle.
Figure 3. Vertical Ground Reaction Forces (vGRFs) comparing Sham and Control Groups
Figure 4. Kinematic data (degrees) of the ankle, knee, and hip in all three planes comparing sham and FRT groups across the entire gait cycle.

Figure 5. Kinetic data (Nm/kg) of the ankle, knee, and hip in all three planes comparing sham and FRT groups across the entire gait cycle.
Figure 6. Vertical Ground Reaction Forces (vGRFs) comparing Sham and FRT Groups.
References


Appendix A

The Problem

Problem Statement After an initial ankle sprain, one’s chance of suffering a subsequent ankle sprain significantly increases. Mechanical and functional deficiencies cause a cascade of events which place the ankle in further predisposing positions especially during activity. During gait, those with CAI walk with more supination and plantarflexion during terminal swing, and heel strike predisposing one’s chance of subsequent ankle sprains.

The Fibular Reposition Taping may potentially provide beneficial effects in those with CAI during gait reducing their risk of recurrent ankle sprains by avoiding those pathological positions. It is also important to examine knee and hip biomechanics since change at the ankle has been shown to alter mechanics up the kinetic chain. Examining knee and hip biomechanics would give clinicians a greater understanding of any alterations throughout the kinetic chain and any potential influence from FRT application.

Research Questions Will there be any differences in ankle moments throughout the entire gait cycle when comparing FRT, Sham FRT, and no tape groups in individuals with CAI? Will there be any differences in ankle rotation throughout the entire gait cycle when comparing FRT, Sham FRT, and no tape groups in individuals with CAI? Will there be any differences in knee and hip kinetics and kinematics across the entire gait cycle when comparing FRT, Sham FRT, and no tape groups in individuals with CAI? Will there be any difference in vertical ground reaction force during initial heel strike when comparing FRT, Sham FRT, and no tape groups in individuals with CAI?
**Experimental Hypothesis**  We hypothesize that there will be 1) an increase in ankle eversion, dorsiflexion, and external rotation moments for the FRT group when compared to Sham and no tape groups, and 2) no difference in ankle joint moments between sham and no tape group. We hypothesize that there will be 1) an increase in ankle eversion, dorsiflexion, and external rotation for the FRT group when compared to the sham and no tape groups, and 2) no difference in ankle rotation between sham and no tape groups. We hypothesize that there will be no difference in knee and hip kinetics and kinematics across all groups. We hypothesized that there will be no difference in vertical ground reaction force across all groups.

**Assumptions**

- Participants will walk as normal to their regular gait as possible.
- Participants will walk consistently for each trial.
- Diagnostic ultrasound treatment, a part of a bigger study, will not affect participants’ gait biomechanics.
- Participants will honestly respond to all inclusion and exclusion criteria.

**Delimitations**

- Participants 18-40 years of age since this population will be more likely to be active.
- Participants with CAI according to the International Ankle Consortium criteria.
- Participants who are active on a weekly bases according to the Godin Leisure Form.
- Participants without a history of lower extremity surgery.
- Participants without a history of an ankle fracture.
• Participants with multiple ankle sprains with the first sprain occurring greater than a year ago, and without an acute ankle sprain six weeks prior to study.
• Participants without a vestibular disorder determined by participants.

**Limitations**

• Hardware limits data collection to one gait cycle instead of multiple.
• Participant learning effect may occur due to one session of data collection.
• Hardware from MotionMonitor and set-up may alter normal biomechanics of gait.
• Artificial noise may have occurred due to the wired electromagnetic sensors and platform.
• We did not screen for participants with pes planus, pes cavus, or differentiate if participants had bilateral or unilateral CAI.
• We accepted both and tested their perceived worst ankle.
• Taping both ankles for the purpose of colleague’s study.
• Gait biomechanics data measured unilaterally instead of bilaterally.
• The longevity of the tape and its effects are unknown.
• We were unable to measure whether participants actually had an anterior positional fault.
• We still do not know if a positional fault occurs due to repetitive LASs or if a positional fault is a predisposing factor to LASs.

**Operational Definitions**

• **Active Adults:** an individual between the ages of 18 and 40 who scores ≥24 on the Godin Leisure Questionnaire.
• **Chronic Ankle Instability:** occurrence of repetitive bouts of lateral ankle instability, resulting in numerous ankle sprains.

• **Curve Analysis:** Mean and confidence intervals of treatment groups throughout the gait cycle represented by 100 points of the gait cycle.

• **Fibular Repositioning Taping:** taping technique using Cover-Roll® stretch tape beginning on the lateral malleolus, wrapping around the Achilles tendon, and finishing on the anterior distal shaft just above the tibiofibular syndesmosis. The same pattern is completed with Leukotape®, however with significant tension.

• **Initial Heel Contact:** The beginning of the stance phase during one gait cycle.

  **Kinematics:** The branch of mechanics concerned with the motion of objects without reference to the forces that cause the motion.

• **Kinetics:** The study of forces acting on the hip, knee, and ankle such as vertical and lateral ground reaction forces.

• **Risk Factor:** A condition or behavior that increases risk of injury.

• **Sham Fibular Repositioning Taping:** same exact procedure and supplies as described for Fibular Repositioning Taping, however with no tension with the Leukotape®.

• **Swing:** The end of the swing phase during one gait cycle.

• **Terminal Complete Gait Cycle:** Begins with heel contact and ends with terminal swing of the ipsilateral lower extremity.

• **Toe Off:** The end of the stance phase during one gait cycle.

• **Vertical Ground Reaction Force:** The vertical reaction force of the ground on the heel during the stance phase of gait.
**Significance of Study** FRT may be an effective prophylactic technique for those with CAI. This study identifies any FRT contributions on lower extremity gait kinetics and kinematics. The technique requires less time for application, and less material potentially saving time of application and money for supplies compared to the traditional basket weave technique. The FRT may also be more comfortable for the patient since it can fit inside a shoe easier, and is not as bulky compared to ankle braces or the traditional basket weave technique. Therefore, FRT application may potentially be a significant clinical technique, serving either as a therapeutic or prophylactic treatment in regards to gait biomechanics in individuals with CAI.
Appendix B

Literature Review

Purpose

The purpose of this review is: 1) to review functional anatomy of the ankle, knee, and hip, 2) review the etiology and prevalence of Chronic Ankle Instability (CAI), 3) specifically review the fibular fault mechanism as a result of CAI, 4) review the biomechanics of gait of those with CAI, 5) review the known alteration in biomechanics of gait after ankle tape or brace intervention, 6) and finally review the preliminary known effects of the Fibular Repositioning Taping technique in regards to CAI.

Functional Anatomy of the Ankle

Talocrural Joint Surrounded by a thicker joint capsule posteriorly than anteriorly, the talocrural joint is a close-fitting articulation that reaches a closed-packed position as it nears end ranges of dorsiflexion. Since, majority of the talocrural ligaments are integrated within the surrounding joint capsule, injury to those ligament will cause joint capsule damage and irritation to the synovial lining except for the calcaneofibular extracapsular ligament. The talocrural joint has one degree of freedom of movement in the sagittal plane involving dorsiflexion and plantarflexion, however due to the close anatomical connection to the foot structures; a pure sagittal unilateral plane of motion is almost nonexistent especially in a closed chained position. When weight bearing, the bone to bone articulations are the primary stabilizers and resisters to rotation and translations motions; however during non-weight-bearing the ligamentous and tendinous structures are primarily responsible for resisting against those same motions.
**Subtalar Joint** The articulation of the calcaneus and the talus make-up the subtalar joint and provide one degree of freedom in the frontal plane involving pronation and supination around an oblique axis.¹ However, the subtalar joint, the talocrural joint, the midtarsal joints, and the tibiofibular joint functionally work together to produce pronation and supination.⁴ Pronation and supination motions cause joint alterations up the kinetic chain. Pronation will force internal tibial rotation, knee flexion, followed by internal hip rotation, while the opposite occurs during supination which is external tibial rotation, knee extension, and external hip rotation.¹ When weight-bearing the talar head moves on the calcaneus and when non-weight-bearing the calcaneus moves on the talus.¹

**Distal Tibiofibular Syndesmosis** The distal tibia and distal fibula make-up the tibiofibular syndesmosis and they are held together by the anterior and posterior tibiofibular ligaments as well as the crural interosseous membrane. This arrangement is important for allowing slight spreading and rotation of the mortise which allows for necessary movement above and below through the kinetic chain. It also allows for slight inferior translation of the distal fibula during weight bearing which deepens the ankle mortise, increases interosseous membrane resistance which then enhance stability.² During dorsiflexion, the interosseous membrane and the tibiofibular ligaments go into a more horizontal position due to lateral and superior translation of the distal fibular.¹ Due to the congruency and perpendicular alignment of the tibiofibular ligaments, the ankle is in its most stabile position at this point. Contrary, under plantarflexion, the distal fibula translates inferiorly and medially placing the tibiofibular ligaments and the interosseous membrane in a more vertical alignment which causes instability.²,⁵
**Interosseous Membrane** The interosseous membrane is a strong fibrous tissue that connects the tibia and fibula, and serves as the origin for many of the lower leg muscles that act on the foot and ankle. Distally, the interosseous membrane merges into the anterior and posterior tibiofibular ligaments supporting the distal tibiofibular syndesmosis joint.

**Muscles Acting on the Ankle** The anterior compartment muscles concentrically dorsiflex the foot while the tibialis anterior is the primary mover for dorsiflexion and supination. The lateral compartment muscles are the peroneal longus and peroneal brevis and their main contribution is ankle eversion and plantarflexion. The peroneal muscles are essential for control supination of the rearfoot and protecting against lateral ankle sprains. The superficial posterior compartment muscles are the gastrocnemius, the soleus, and the plantaris. Together all three cross both the knee and ankle joint and are considered the triceps surae muscle group. This group causes plantarflexion to occur at the ankle and plays an important role in toe-off during gait. The deep posterior compartment muscles as a whole cause plantarflexion and inversion at the ankle. The tibialis posterior is a major contributor in controlling plantarflexion during walking or running. It also works in conjunction with the tibialis anterior forming a force couple. Together, they increase arch stiffness and supinate the foot during heel strike to create a rigid segment avoiding the pronated predisposing position.

**Functional Anatomy of the Knee**

**Articulations and Ligamentous support** The femoral condyles classify the tibiofemoral joint as a double condyloid articulation capable of three degrees of freedom. Those motions are flexion/extension, internal/external rotation, and abduction/adduction.
Any ligament that is hyper or hypomobile will decrease knee stability by negatively affecting the remaining ligaments in the knee.¹

**Joint Capsule** A fibrous joint capsule surrounds the knee joint along the medial, lateral, and anterior aspects arising from the superior femoral condyles and attaching distal to the tibial plateau.¹ The knee joint is stabilized medially by the medial collateral ligament, medial patellofemoral ligaments, and medial patellar retinaculum. The knee is stabilized laterally by the lateral collateral ligament, lateral patellar retinaculum, lateral patellofemoral ligament, and iliotibial band. Finally, the knee is stabilized anteriorly by the patellar tendon and posteriorly by the oblique popliteal ligament and arcuate ligaments. Further stabilization comes from the dynamic stabilizing muscles that cross the knee joint.¹

**Collateral Ligaments** Stabilizing the knee on the medial aspect, the medial collateral ligament (MCL) is the primary medial stabilizer of the knee and is made up of both a deep and superficial layer.¹ The deep layer is more like a thickening of the medial joint capsule and has an attachment on the medial meniscus. The superficial ligament (smaller in width) is aligned slightly anterior and follows a superoposterior to inferoanterior path while crossing the joint starting below the adductor tubercle.¹ In full knee extension the two segments are tight, but during mid-range knee flexion the anterior fibers tight and the deep are loose. The MCL resists primarily against valgus forces and secondarily to external tibial rotation.¹

Contrary to the MCL, the lateral collateral ligament (LCL) does not have an attachment to the joint capsule or meniscus.⁷ When the knee is between full extension
and 30° of flexion the LCL primarily resist against varus forces. The LCL also resists against tibial external rotation as well as secondary resistance to internal tibial rotation.

**Cruciate Ligaments** The cruciate ligaments of the knee are the Anterior Cruciate Ligament (ACL) and the Posterior Cruciate Ligament (PCL). Both are located outside the joint capsule, and help stabilize and resist valgus and varus forces. The ACL serves as a static stabilizer against anterior translation, internal rotation, external rotation of the tibia on the femur, and hyperextension of the entire knee joint. When the knee goes from the extended to flexed, the two bundles of the ACL rotate positions. This causes the ACL to wrap around itself causing the anteromedial bundle to become tight and the posterolateral bundle to become loose.

The amount of strain on the ACL is dependent on the direction that the tibia translates in regards to the femur. For instance, during knee extension, more tibial internal rotation will cause greater stress on the ACL as compared to external tibial rotation. Increased ACL strain also occurs during valgus and varus stresses, but at a lesser amount. During open kinetic chain motions, the greatest amount of ACL stress occurs during the last 30° of knee extension, and it increases more when resistance is added.

**Posterolateral Corner** The posterolateral corner structures of the knee are made-up of three separate layers. The superficial layer consists of the lateral fascia, iliotibial tract, and biceps tendon. The middle layer consists of the patellar retinaculum, and the patello-femoral ligament. The deepest layer consists of the capsule, the lateral collateral ligament, the arcuate ligament, the fabello-fibular ligament, popliteofibular ligament, and the tendon of the popliteus. Primary translations and rotations occur along the axis of
the applied force or moment, whereas coupled translations and rotations occur in directions different to the applied force. The most common mechanism of injury to the posterolateral structures is a combined hyperextension and varus force to the knee. Nielson et al., demonstrated the importance of the posterolateral structures in resisting excessive varus and external rotation forces. The LCL and the posterolateral part of the capsule resisted varus and external rotation of the tibia, with the former having a greater role against a varus moment and the latter, a greater role against external rotation torque. Also, the popliteus tendon resists excessive external rotation of the tibia during knee flexion from 20° to 130°, and it resists excessive varus rotation of the tibia during flexion from 0° to 90°.

**Proximal Tibiofibular Syndesmosis** The proximal tibiofibular ligament is an arthrodial plane joint composed of the tibial facet on the posterolateral aspect of the rim of the tibial condyle and the fibular facet on the medial upper surfaces of the head of the fibula. The superior anterior tibiofibular ligament consists of two to three flat strong bands while the superior posterior tibiofibular ligament only has one band. The primary function of the joint is to dissipate torsional stresses applied to the ankle, dissipate lateral tibial bending moments, and provide tensile, rather than compressive weight bearing. Approximately one-sixth of static load applied at the ankle is transmitted along the fibula. Also, the proximal and middle one-third fibula has greater tensile strength than the femur. As the knee moves into extension in an open kinetic chain position, the fibular head is pulled posterior as the lateral collateral ligament and biceps femoris become taunt. Knee flexion produces an anterior movement due to the relaxation of the LCL and biceps femoris tendon. During closed kinetic chain positions, these movements may
differ due to the movements occurring at the distal tibiofibular and talocrural joints. As the ankle undergoes dorsiflexion, the talus must externally rotate which causes lateral and external rotation of the fibula.16

The Menisci The knee joint menisci are a pair of wedge shaped semilunar cartilages interposed between the femoral condyles and tibial plateau which are also attached to the joint capsule.18 The contact between the tibiofemoral joint increases significantly due to the deepened congruency of the menisci which overall reduces the stresses on the tibial cartilage.19 Approximately 70% and 50% of the loads through the lateral and medial compartments occur during loaded in vitro situations.20 Loading distribution is an important mechanism made possible by the strong anterior and posterior entheses to the bone which hold the menisci in place and doesn’t allow them to extrude from the joint during loading. Axial joint loading will place tension on the insertional ligaments and the circumferential fibers of the meniscus which is transformed into hoop stresses at the meniscal periphery.18 During knee flexion and extension, the lateral meniscus displaces approximately 10 mm on the tibial plateau, which is twice as much than that of the medial meniscus.21 The primary function of the menisci are to assist with shock absorption,22 joint stabilization,23 and joint lubrication.24

Chronic Ankle Instability

Pathomechanics CAI is thought to be different from an initial acute injury. However damage to soft tissue structures after an initial ankle sprain is believed to predispose individuals to subsequent sprains.25 Two theories have been proposed to explain the causes of CAI: mechanical instability and functional instability. However, further
investigation of the cause of each instability may give clinicians a better understanding of
the potential causes of CAI.³

Mechanical instability is the anatomical changes that occur to the ankle complex
after an initial ankle sprain. Specific injury includes pathologic laxity, impaired
arthrokinematics, synovial changes, and development of degenerative joint disease.³
Damage to the ligaments of the ankle cause the joint to be mechanically unstable.³
Pathological laxity occurs more so when the ankle is put into vulnerable positions
causing more stress the joint and ligaments.³ More commonly, the talocrural and subtalar
joints suffer pathological laxity after an inversion ankle sprain.²⁶

Arthrokinematic impairments may also occur after repetative ankle sprains. A
specific impairment involves joint structure change which occurs at the distal tibiofibular
joint in which the distal fibula translates anteriorly and inferiorly causing an
arthrokinematic impairment.²⁷ This causes laxity of the ATF ligament since the distal
fibula is closer to the talus. In this case, when the foot undergoes supination, the ATF
goes through a greater range of motion before becoming taunt which is a risk factor for a
subsequent sprains to occur.³ Dorsiflexion restrictions typically exist in those with CAI
and cause subsequent sprains because the talocruhal joint cannot reach its closed-pack
position in which it is most stable. This is an issue during gait when the ankle needs to be
in this position during heel strike in order to attenuate forces properly.³

Synovial and degenerative changes may influence mechanical instability in those
with CAI. After an ankle sprain, synovial hypertrophy and impingement of joint soft
tissues occur. This can lead to the onset of degenerative joint lesions which would display
symptoms of pain and ankle instability. Synovial inflammation has often been reported and shown in the talocrural and posterior subtalar joint capsules. Functional ankle instability arises from damage that occurs to the neuromuscular system which dynamically provides stabilization for the ankle. Since the lateral ligaments of the ankle complex have shown to by innervated by mechanoreceptors, damage to those structures will cause sensation deficiencies in which joint position sense is diminished. Impaired position sense diminishes the efferent response which is responsible for placing the joint in a stabilie position. 

Neuromuscular insufficiencies also contribute to functional ankle instability. Receptors within muscles and tendons are capable of sensing joint position and can also become deficient after injury. Impaired firing patterns have been shown to occur within the peroneal muscles affecting their ability to evert the ankle and protect it from hypersupination and inversion. Impaired postural control is also common in those with CAI. This is more likely due to a combination of deficiencies in proprioception and neuromuscular control. Finally, strength deficits for both inversion and eversion have also been shown to exist in those with CAI. 

Population of Prevalence After a LAS, athletes report a greater number of residual complaints and are at an increased risk of sustaining similar injuries compared to individuals who participate in less demanding activities. Individuals who also participate in team and court sports, as well as games that include contact, jumping maneuvers, and/or indoor play are at an increased risk of sustaining further lateral ankle sprains. Amongst these sports, soccer and basketball athletes have the highest percentage of participants with recurrent ankle sprains because both are multidirectional
sports that involve dynamic movement patterns that include running, cutting, and jumping during complex environments.  

High school athletes may be at an increased risk of suffering CAI in comparison to collegiate athletes. College athletic programs have the funds to provide athletes more resources than high school athletes. For instance, colleges can afford more coaches, strength and conditioning coaches, and athletic trainers who can implement prophylactic taping or bracing, conduct preventative warm-up and stretching protocols, as well as carry out comprehensive rehabilitation programs. In addition, collegiate athletes naturally have a greater skill set, are more mature, and therefore more in sync with their bodies which may lower their chance of suffering from CAI.

It has been suggested that females may be more at risk of suffering a LAS compared to their male counterparts. It has been found that intercollegiate female basketball players had a 25% greater chance of suffering a grade I ankle sprain. This may be true do to females’ increased calcaneal eversion, tibial varum, increased ankle laxity, and decreased postural control.

**Diagnosis of CAI** Past clinicians have developed and implemented multiple techniques for clinically diagnosing CAI. Several self-reporting questionnaires have been designed and tested for reliability by researchers to serve as an objective measure. As of 2014, eight different self-assessment tools for assessing individuals with CAI exists and those are: The Ankle Instability Instrument (AII), Ankle Joint Functional Assessment Tool (AJFAT), Chronic Ankle Instability Scale (CAIS), Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Ability Measure (FAAM), Foot Ankle
Instability Questionnaire (FAIQ),\textsuperscript{50} Foot and Ankle Outcome Source (FAOS),\textsuperscript{45,51} and Identification of Functional Ankle Instability (IdFAI).\textsuperscript{38}

Another clinical technique used in diagnosing CAI is the dynamic anterior ankle tester (DATT) which theoretically has the ability to detect increased ligament laxity; however evidence suggests that the DATT is unreliable.\textsuperscript{52} Nauck et al., developed a non-radiographic ankle arthrometer to objectively assess mechanical ankle instability.\textsuperscript{53} This procedure has accurately demonstrated sensitivity in differentiating unstable from stable ankles\textsuperscript{53} therefore ruling out potential incidences of CAI. Lastly, Knapp et al., attempted to use force-plate postural control measures to assess CAI, but this method did not prove to be an effective technique for diagnosing CAI.\textsuperscript{54}

Magnetic resonance imaging (MRI) to detect ankle lesions, which are common in CAI individuals, has been questioned as data suggests low sensitivity measures.\textsuperscript{55} It has been found that MRI may be less reliable when compared to arthroscopy.\textsuperscript{56} Negative MRI results for symptomatic CAI patients should be viewed cautiously and may still need arthroscopy for confirmation. The use of ultrasonography in assessing damage to the ATFL in athletes with CAI after an ankle sprain has shown to be favorable, but second to radiography.\textsuperscript{57} MRI has also been determined useful for detecting peroneal tendinopathy in patients with chronic lateral ankle instability (CLAI), however vague in some instances. With that said, when diagnosing patients with CAI, a detailed physical examination including thorough history, patient symptoms, functional deficiencies, and careful use and/or collaboration of imaging techniques should be used.\textsuperscript{58}

**Gait Biomechanics**

**Stance Phase**
**Initial Contact** During initial contact, the loading response is initiated when the dorsiflexors become eccentrically active in order to control the rate of plantarflexion and foot placement onto the surface. The subtalar joint pronates, creating a shock-absorbing mechanism while the inverters eccentrically activate in order control this motion. The hip remains in a neutral adduction-abduction position and is externally rotated approximately 5 degrees while the knee is in near to full extension. To assist in the initial loading response, the hip and knee both will undergo a degree of flexion in order to assist in force absorption.\(^1\)

**Mid Stance** During midstance, the plantarflexors activate eccentrically to control movement of the tibia over the stationary foot while also stabilizing the knee during the single limb phase. The subtalar joint begins to supinate as the foot becomes flat on the surface while the talocrural joint reaches about 15 degrees of dorsiflexion. Early in midstance, the hip reaches maximum adduction to reduce side-to-side sway. Additionally, the knee undergoes approximately 20 degrees of flexion again to help attenuate forces, however towards the end of midstance, the knee undergoes extension and returns close to full extension.\(^1\)

**Terminal Stance** During terminal stance, the weight is shifted over the metatarsal heads as the body progresses over the supporting foot. The dorsiflexors remain isometrically activated while the plantarflexors begin to transition from eccentric to concentric contraction in order to propel the body forward. The hip undergoes extension and abduction to assist in stride length while the knee remains in an extended state following midstance for forward progression and to reduce vertical displacement.\(^1\)
Preswing The transitional phase of double limb support in which the previous support limb quickly disengages from the ground and prepares for swing. While the weight is positioned over the first metatarsalphalangeal joints, the plantarflexors activate concentrically to generate force for pushing off.\(^1\)

Swing Phase

Initial Swing Initial swing begins once the toe pushes off the ground creating a propulsive force. Hip and knee flexion occur in addition to activation of the dorsiflexors in order to achieve toe clearance.\(^1\)

Mid Swing During mid swing, the hip continues to further flex and abduct to again assist in toe clearance. The knee continues to extend which is necessary for continued forward motion. Finally, the dorsiflexors continue to active concentrically to ensure toe clearance.\(^1\)

Terminal Swing The thigh decelerates to prepare for heel contact, while the knee extends to maximize step length. The hamstrings and glutes assist in preparation of heel contact by controlling acceleration of the knee. Again, the dorsiflexors activate concentrically in order to expose the heel for initial contact.\(^1\)

Altered Gait Patterns of CAI Population

After an inversion sprain, damage often occurs to the joint capsule, ligaments, and to mechanical receptors which play a role in the proprioceptive system. As a result, alterations in gait patterns typically follow. A study by Chinn et al., found that individuals with CAI, when jogging, were more plantarflexed from 54 to 68% of the gait cycle compared to the healthy control group.\(^59\) The same participants demonstrated more inversion in three different increments from 11% to 18%, 33-39%, and 79-84% of the
Lastly, the also had on average 3° less dorsiflexion during mid to late stance of gait.  

Patients with CAI have also shown to maintain an inverted state throughout the period from 100 ms pre-heel strike to 200 ms post-heel strike. During the same period, the immediate 5 ms prior to and post-heel strike, experimental and control groups experienced different angular velocity at the ankle. During this time, CAI individuals inverted approximately 0.5 rad/s while the control everted at a rate of 0.1 rad/s. Contrary, Ridder et al., found that CAI patients were in greater eversion from 11%-73% of the stance phase. The ankle tended to evert maximally early in the swing phase, but later towards the end of the swing phase, would subsequently invert. These altered gait patterns may put the ankle into vulnerable positions increasing the risk for subsequent ankle sprains in individuals with CAI compared to others with healthy ankles.

**Fibular Positional Fault**

First proposed by Mulligan et al., after an inversion ankle sprain, the fibula translates forward at the inferior tibiofibular joint causing an anterior positional fault. Mechanical alterations occur and cause damage to the lateral ligaments such as the ATFL, cervical, and calcaneofibular ligaments which hold the fibula in place against the distal tibia and lateral aspect of the talus. During an inversion sprain, extreme stresses of the ATFL pull the distal fibula forward. This causes irregular joint arthrokinematics, mechanoreceptor trauma, and deficient afferent and efferent response.

Mechanically, an anterior positional fault serves as a mechanism for subsequent LASs in individuals with CAI. However, it may be possible that mechanical deficiencies do not exist. A study by Hubbard et al., found significant differences in distal
fibula positioning when compared within CAI participants with unilateral CAI.\textsuperscript{62}  
Contrary, three separate studies identified the opposite in which the distal fibula becomes posteriorly positioned.\textsuperscript{63-65} Furthermore, Kobayashi et al., found conflicting evidence in which there is no anterior or posterior difference in distal fibula positioning.\textsuperscript{66} Instead, they suggest that the distal fibula is in fact positioned more laterally when comparing CAI individuals to control counterparts.

With all of that being said, it is majorly important to mention that each of the previously mentioned studies used a variety of measuring techniques as well as subjects for data collection. Some examined the distal fibula after an acute ankle sprain instead of CAI which may cause differences in results. Overall, it is safe to assume that a mechanical deficiency whether repositioning of the distal fibula, or damage to the ligaments will exist in those with CAI. Do to the structural alterations, functional deficiencies typically follow and further contribute to the injury cascade.

**Fibular Reposition Taping**

Fibular reposition taping (FRT) is a therapeutic taping technique used to correct a positional fault. After an inversion ankle sprain, the distal fibula becomes malaligned, also known as an anterior positional fault, causing irregular joint arthrokinematics which overtime predisposes patients to further ankle sprains. Specifically, the purpose of FRT is to realign the distal fibula in its proper position restoring regular articulations with the tibia and talus. In recent years, FRT has been evaluated for its effects on ankle kinematics, prevention of ankle sprains, postural control, dorsiflexion range of motion, and lower leg neuromuscular reflexes.
In 2006, Moiler et al., conducted a pilot study examining the prevention of ankle sprains with the use of FRT in young male basketball players. Subjects were assigned to either the FRT group in which both ankles were taped or to the control group. The control group was given the choice on the use and type of prophylaxis excluding FRT. Overall, 443 measured basketball exposures resulted in 11 ankle sprains with significantly less occurring in the FRT group (n = 2) and more occurring for the control group (n = 9). The results of this study suggest that FRT is effective in preventing LAS.

A study by East et al., examined the effects of FRT on ankle kinematics and lower extremity muscle activity during a single leg landing task. A total of 30 subjects with CAI were randomly assigned to treatment (FRT), placebo tape, or control group and their single leg measurements were taken before and after intervention. Results indicated that the FRT group landed in less plantarflexion at ground contact and demonstrated decreased tibialis anterior extremity muscle activity prior to ground contact. This study suggests that FRT may enhance lower extremity kinematics and alter muscle activation, and therefore may increase joint stability and reduce the risk of injury associated with CAI.

In 2013, a study by Chou et al., examined the influence of FRT on neuromuscular function of the peroneus longus and the soleus h-reflex amplitude in patients with CAI. Twelve subjects were randomized to FRT group or sham group and crossed over with measurements taken before and after each intervention. The h-reflex and M-wave was measured for both the soleus and the peroneus while the v-wave was only measured for the soleus. The main significant finding was that an increase in h/M ratio in the soleus for the FRT group occurred. No differences were found in peroneus longus h/m ratio or
soleus v/M ratio for either FRT or sham group. Since the peroneal muscles act to resist against the inversion mechanism, it is disappointing to see that the peroneal h/M ratio did not change for the FRT group. However, it is relevant that the soleus h/M ratio increased and this shows that FRT is able to cause changes at the neuromuscular level.69

In 2015, a study by Someeh et al., evaluated the effect of FRT on postural control in professional athletes with CAI. Sixteen athletes with unilateral CAI and sixteen healthy athletes participated and underwent FRT and no tape conditions. Star excursion balance measurements in the anteromedial, medial, and posteromedial directions were measured for both groups in the two conditions. For both groups, FRT significantly improved postural control in all three test directions. These results suggest that FRT has a major impact on postural control by enhancing the proprioceptive system for CAI and healthy athletes. Additionally, FRT may be useful for increasing proprioception for those with CAI, but may also be used to improve balance for those without CAI.70

A study by Delfa-De-La Morena et al., examined the effects of FRT on static and dynamic postural balance in only healthy subjects. Forty-four healthy subjects were randomized to FRT or placebo groups and underwent the Sensory Organization Test and the Motor Control Test before and after intervention. The study’s major findings were that the FRT tape did not have an impact on postural control during static and dynamic balance for the treatment group when compared to the placebo group. Since no difference exist for equilibrium and strategy, or for speed of reaction in any of the healthy subjects, FRT may not be effective in enhancing balance in healthy individuals.

Similarly, Wheeler et al., examined the effects of FRT on dorsiflexion range of motion in addition to dynamic balance in individuals with CAI. Twenty-three subjects
with CAI were randomized to either the FRT or sham group and then were crossed over for a second treatment. Dorsiflexion measures and components of the Star Excursion Balance Test were taken before and after intervention. No significant differences existed between groups for the dorsiflexion measurements, however both groups slightly increased. FRT produced an increase in posterolateral reach distance compared to sham group, but the difference did not exceed the established minimal detectable change. No significant difference were observed between groups in the anterior reach distance. FRT and sham FRT showed to slightly increase dorsiflexion while FRT demonstrated a slight increase in posterolateral reach distance, but those differences were not clinically significant. The results of this study suggests that FRT application is incapable of increasing dorsiflexion as well as enhancing balance in individuals with CAI minimally.71

In 2015, a study by Someeh et al., evaluated the effects of FRT on functional performance (FP) tasks in athletes with and without CAI. Sixteen professional athletes with unilateral CAI and sixteen uninjured professional athletes were randomized to FRT or no tape conditions and subjects were crossed over for comparison. Functional performance tests included single leg hopping, figure-of-8 hop and side hop while measurements were taken for both groups before and after interventions. The intervention improved FP test measurements for both groups, and significant difference existed between injured and uninjured participants. The results of this study suggest that FRT can effectively improve functional performance in both healthy athletes and athletes with CAI.72
Appendix C: Additional Methods

Executive Summary

University of Toledo

Title: Effects of the Fibular Repositioning Taping on Lower Extremity Biomechanics during Gait in Active Adults with Chronic Ankle Instability.

Project Supervisor: Neal Glaviano, PhD, ATC

Research Team: Luke Donovan, PhD, ATC (Co-Investigator)
Charles Armstrong, PhD (Co-Investigator)
John McCleve, ATC (Co-Investigator)
Caroline Fitch, ATC (Co-Investigator)

Purpose:

The main purpose of this study is to examine the clinical effects of FRT application on triplanar hip, knee, and ankle kinetics, and kinematics during gait within patients with CAI.

Participants:

20 subject between the ages of 18-40 who qualify as having CAI, and are currently active on a weekly basis.

Inclusion Criteria:
All Participants:

- Between the age of 18-40
- Have a history of more than 1 ankle sprain occurring greater than 1 year ago
- Score < 85% on FAAM Sport questionnaire
- Score ≥11 on the Identification of Functional Instability scale (IdFAI)
- Score ≥ 24 on Godin’s Leisure Time Exercise Questionnaire

Exclusion Criteria:

All Participants:

- Had a history of an ankle fracture on either ankle
- Had a history of an ankle surgery on either ankle
- Had an acute ankle sprain within 6 weeks prior to data collection
- Had any vestibular disorder

Study Design:

Crossover repeated measures laboratory design

Independent Variables: Conditions

- Fibular Reposition Taping
- Sham Fibular Reposition Taping
- Control – No Tape
**Dependent Variables:** Triplanar Data

- Kinematic Data
  - Hip
  - Knee
  - Ankle
- Kinetic Data
  - Hip
  - Knee
  - Ankle
- Vertical Ground Reaction Forces

**Procedures:**

1. Obtained informed consent
2. Screening (General Health, FAAM Sport, idFAI, Godin Leisure)
3. Sensor Set-up
4. Treatment 1
5. 10 Walking Trials
6. Treatment 2
7. 10 Walking Trials
8. Treatment 3

**Statistical Analysis:**
A Time Series Analysis will be conducted for all conditions and measured across 100 points of the gait cycle. Group means and 90% confidence intervals will be graphed. Significance will be identified when 3 or more consecutive confidence intervals do not overlap.

**Research Hypothesis:**

1. It is hypothesized that there will be 1) an increase in ankle eversion, dorsiflexion, and external rotation moments for the FRT group when compared to Sham, and no tape groups 2) no difference in ankle eversion/inversion, dorsiflexion/plantarflexion, and internal/external rotation moments between sham and not tape group 3) no differences in knee moments across groups, and 4) no difference in hip moments across groups.

2. It is hypothesized that there will be 1) an increase in ankle eversion, dorsiflexion, and external rotation for the FRT group when compared to the sham and no tape groups, 2) no difference in ankle eversion/inversion, dorsiflexion/plantarflexion, and external/internal rotation between sham and no tape groups, 3) no differences in knee flexion/extension, adduction/abduction, or internal/external rotation across groups, and no differences in hip flexion/extension, adduction/abduction, or internal/external rotation across groups.

3. It is hypothesized that there will be 1) a decrease in vertical ground reaction forces for the FRT group when compared to the sham and no tape groups, and
2) no difference in vertical ground reaction force when comparing sham and no tape groups.
RESEARCH SUBJECT INFORMATION AND CONSENT FORM

Lower Extremity Gait Kinematics in Chronic Ankle Instability Individuals and Diagnostic Ultrasound on Distal Fibula and Talar Distance

Principal Investigator: Neal Glaviano, PhD, ATC (Lead Investigator)

Other Staff (identified by role): Grant Norte, PhD, ATC (Co-Investigator)
Luke Donovan, PhD, ATC (Co-Investigator)
Charles Amstrong, PhD (Co-Investigator)
John McCleve, ATC (Co-Investigator)
Caroline Fitch, ATC (Co-Investigator)

Contact Phone number(s): (419) 530-4501 (Neal Glaviano)
(616) 490-1740 (John McCleve)
(484) 767-5325 (Caroline Fitch)

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 a taping technique affects your ankle, knee, and hip positions during walking. The bone position in your ankle will also be assessed using ultrasound. The purpose of the study is to examine the difference in how your lower legs function with different taping techniques. You were selected as someone who may want to take part in this study.
NO TEXT THIS PAGE
because you are between the ages of 18 and 40 years old, and may be identified as having chronic ankle instability in at least one ankle. This research study will be conducted in the Musculoskeletal Health and Movement Science Laboratory at the Health Science and Human Service Building at the University of Toledo Main Campus. We will be enrolling 20 subjects for this study.

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. You will perform a controlled walking task while we record your leg movement. Afterwards, you will also be asked to lay down on a cushioned examination table for 10 minutes while we take measurements between the bones of your ankle using the ultrasound. Your entire testing session will take approximately 2 hours.

Eligibility Screening
Before you can officially enroll in this study, you will be given multiple questionnaires to determine your eligibility. You will be given a general health questionnaire, the Foot and Ankle Ability Measure Sport sub-scale, the Godin Leisure Time Exercise Questionnaire, and the Identification of Functional Ankle Instability. The general health questionnaire will ask questions similar to ones you would be asked in a health history screening at your doctor’s office. All female participants will be asked to disclose if they may be pregnant. There are no known risks to unborn children or pregnant women at this point. The other questionnaires will help researchers determine your eligibility for the study by asking about how well your ankle functions, as well as your physical activity level. These will take about 10 minutes to complete.

Warm-Up
It will not be necessary to warm-up before undergoing ultrasound. However, before the walking task you will have as much time as you need to adequately warm-up and prepare.

Treatment
You will receive 3 treatments in a random order: no tape, ankle taping 1, and ankle taping 2. The materials we will be using to complete the tappings are tape adherent, Cover-Roll, and Leukotape. Tape adherent is a spray that will help the tape stick better, Cover-Roll is a sticky mesh cloth tape, and Leukotape is a sticky sturdy tape.

Diagnostic Ultrasound
We will use a clinical tool called diagnostic ultrasound on your ankle to take measurements of bone position.

Walking Task
First, we will place wired sensors to your involved foot, lower leg, thigh, hip, and spine so that we can measure joint angles of the hip, knee, and ankle. Then you will be given the chance to warm-up. When you are ready, we will ask you to walk as normal as possible while trying to land on the force platform with your involved ankle. When you feel ready, you will repeat the same task for a total of ten trials. This same process will be repeated a total of three times.

RISKS AND DISCOMFORTS YOU MAY EXPERIENCE IF YOU TAKE PART IN THIS RESEARCH
Likely Risks
- The tape or ultrasound gel may cause skin irritation.
The walking task may cause muscle soreness or foot discomfort. You will be offered ice bags after participation to reduce the risk of soreness and discomfort.

There is also the risk of falling or losing balance.

Unlikely Risks

- Injury to your foot or ankle. This risk is unlikely if you have been cleared for full activity according to the health history form.

There are no known risks to unborn children at this point. There may be risks that the researchers are unaware of at this time.

**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 the effects of the Fibular Reposition Taping (FRT) on lower body biomechanics while walking, as well as bone alignment in the ankle in young adults.

**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 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. If you receive any payments for taking part in this study, your personal information and limited information about this study will be given to The University of Toledo’s accounts payable department as necessary to process payment to you. 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.
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, 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 419-383-6933.

The information that we will use or disclose will be de-identified information only, and will be used for publication in a scientific peer-reviewed journal. We may use this de-identified information ourselves, or we may disclose or provide access to the information to other researchers conducting similar research, and possibly a statistician to help analyze data collection as part of the research study. This study is not sponsored by any outside agencies. There is not a plan to share this data with any outside agency.

**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 health care 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, 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.
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: Charles Armstrong, PhD at 419-530-5369

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 419-383-6796.

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

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.
General Health History Form

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 (cold, flu, infection, etc.)
☐ Surgery
☐ Other: ____________________________

Please Explain: ________________________________________________________________

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

Please Explain: ________________________________________________________________

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: ____________________________

Please Explain: ________________________________________________________________

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

Please Explain: ________________________________________________________________

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:

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Subject ID Number:

Foot and Ankle Ability Measure (FAAM)
Sports Subscale

Because of your foot and ankle how much difficulty do you have with:

<table>
<thead>
<tr>
<th></th>
<th>No Difficulty at all</th>
<th>Slight Difficulty</th>
<th>Moderate Difficulty</th>
<th>Extreme Difficulty</th>
<th>Unable to do</th>
<th>N/A</th>
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<tbody>
<tr>
<td>Running</td>
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<tr>
<td>Jumping</td>
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<tr>
<td>Landing</td>
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<tr>
<td>Starting and stopping quickly</td>
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<tr>
<td>Cutting/lateral Movements</td>
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<tr>
<td>Ability to perform Activity with your Normal technique</td>
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<td></td>
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<tr>
<td>Ability to participate In your desired sport As long as you like</td>
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</tbody>
</table>

How would you rate your current level of function during your sports related activities from 0 to 100 with 100 being your level of function prior to your foot or ankle problem and 0 being the inability to perform any of your usual daily activities?

___ ___ 0%

Overall, how would you rate your current level of function?

☐ Normal    ☐ Nearly Normal    ☐ Abnormal    ☐ Severely Abnormal


UT IRB# 201476
Assigned Version Date: 09/06/2016

APPROVED BY UNIVERSITY OF TOLEDO IRB
IDENTIFICATION OF FUNCTIONAL ANKLE INSTABILITY (IdFAI)

Instructions: This form will be used to categorize your ankle stability status. A separate form should be used for the right and left ankles. Please fill out the form completely and if you have any questions, please ask the administrator. Thank you for your participation.

Please carefully read the following statement:
"Giving way" is described as a temporary uncontrollable sensation of instability or rolling over of one's ankle.

I am completing this form for my RIGHT/LEFT ankle (circle one).

1.) Approximately how many times have you sprained your ankle? _________

2.) When was the last time you sprained your ankle?
   - Never
   - > 2 years
   - 1-2 years
   - 6-12 months
   - 1-6 months
   - < 1 month

3.) If you have seen an athletic trainer, physician, or healthcare provider how did he/she categorize your most serious ankle sprain?
   - Have not seen someone
   - Mild (Grade I)
   - Moderate (Grade II)
   - Severe (Grade III)

4.) If you have ever used crutches, or other device, due to an ankle sprain how long did you use it?
   - Never used a device
   - 1-3 days
   - 4-7 days
   - 1-2 weeks
   - 2-3 weeks
   - >3 weeks

5.) When was the last time you had "giving way" in your ankle?
   - Never
   - > 2 years
   - 1-2 years
   - 6-12 months
   - 1-6 months
   - < 1 month

6.) How often does the "giving way" sensation occur in your ankle?
   - Never
   - Once a year
   - Once a month
   - Once a week
   - Once a day

7.) Typically when you start to roll over (or 'twist') on your ankle can you stop it?
   - Never rolled over
   - Immediately
   - Sometimes
   - Unable to stop it

8.) Following a typical incident of your ankle rolling over, how soon does it return to 'normal'?
   - Never rolled over
   - Immediately
   - < 1 day
   - 1-2 days
   - > 2 days

9.) During "Activities of daily life" how often does your ankle feel UNSTABLE?
   - Never
   - Once a year
   - Once a month
   - Once a week
   - Once a day

10.) During "Sport/or recreational activities" how often does your ankle feel UNSTABLE?
    - Never
    - Once a year
    - Once a month
    - Once a week
    - Once a day
Godin Leisure-Time Exercise Questionnaire

1. During a typical 7-Day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number).

   a) STRENUOUS EXERCISE
      (HEART BEATS RAPIDLY)
      (e.g., running, jogging, hockey, football, soccer,
      squash, basketball, cross country skiing, judo,
      roller skating, vigorous swimming,
      vigorous long distance bicycling)

   b) MODERATE EXERCISE
      (NOT EXHAUSTING)
      (e.g., fast walking, baseball, tennis, easy bicycling,
      volleyball, badminton, easy swimming, alpine skiing,
      popular and folk dancing)

   c) MILD EXERCISE
      (MINIMAL EFFORT)
      (e.g., yoga, archery, fishing from river bank, bowling,
      horseshoes, golf, snow-mobiling, easy walking)

2. During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?
   
<table>
<thead>
<tr>
<th>OFTEN</th>
<th>SOMETIMES</th>
<th>NEVER/RARELY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.</td>
<td>3.</td>
</tr>
</tbody>
</table>

UT IRB# 201476
Assigned Version Date: 09/27/2016

APPROVED BY UNIVERSITY OF TOLEDO IRB
Subject #: _______________ Investigator initials: ____________
Age: ___________ Height (in): ___________ Weight (lbs): ___________ Gender: ___________
Date of Visit: _______________ Time of Day: _______________

**Right Ankle History:**

1. How many times have you sprained your right ankle?
   Answer: 

2. How many years/months ago was your first right ankle sprain?
   
3. How many years/months ago was your most recent right ankle sprain?
   
**Left Ankle History:**

1. How many times have you sprained your left ankle?
   
2. How many years/months ago was your first left ankle sprain?
   
3. How many years/months ago was your most recent left ankle sprain?
   
**Subjective Questionnaires:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAAM-Sport</td>
<td></td>
</tr>
<tr>
<td>idFAI</td>
<td></td>
</tr>
<tr>
<td>General Health History</td>
<td>N/A</td>
</tr>
<tr>
<td>Godin Leisure-time questionnaire</td>
<td></td>
</tr>
</tbody>
</table>

**INCLUSION CRITERIA**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
| ☐   | ☐  | Age of 18 - 40 years  
| ☐   | ☑  | History of more than one ankle sprain with the first ankle sprain occurring greater than one year ago.  
| ☑   | ☐  | Self-reported ankle deficits qualified by a score of < 85% on the Foot and Ankle Ability Measure (FAAM) Sport Scale.  
| ☑   | ☐  | Self-reported ankle deficits qualified by a score of ≥ 11 on the Identification of Functional Ankle Instability scale (idFAI).  
| ☐   | ☐  | Involved in moderate to vigorous physical activity at least 3 times per week as determined by a score of ≥ 24 on the Godin’s Leisure Time Exercise Questionnaire.  

**EXCLUSION CRITERIA**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
| ☑   | ☐  | History of ankle fracture  
| ☑   | ☐  | History of ankle surgery  
| ☑   | ☐  | An acute ankle sprain within 6 months prior to data collection  
| ☑   | ☐  | Any vestibular disorder  

Assigned Version Date: 09/06/2016
Step-by-Step Procedures

1. Load appropriate user ID, system parameters, and preference (Right or Left) files in Motion Monitor (MM).
2. Go to Setup > Edit Sensor Assignments

3. Delete Thorax Sensor, keep sacrum sensor, keep moveable sensor, and adjust remaining sensors to either right or left depending on the limb being tested. For the Right limb, sensor assignment would be as follows:
For the Left limb, the sensor assignment would be as follows:

4. Go to Setup > Setup Stylus > Select Setup New Stylus, and click okay then let sensors initialize.

5. Click stylus button when MM asks to attach sensor #5 to stylus

6. MM will then ask to identify 10 different positions on force plate. While sitting off to the side, begin with tip of stylus on center on approximately a 60° angle and press firmly into the force plate. While slowly rotating the stylus on its point at the approximate angle, click the button 10 different times in a sequenced pattern spacing the amount of times you press the button evenly.
When finished you should have an RMS error value less than 0.002. The lower the better.
7. Setup World Axes > Click okay to special Note MM gives > Select define new axis system > Change “Positive Z Axis” to “Negative Z axis then click okay

A box that says “Initializing Sensors” will pop up. Following, another box will ask to attach sensor #5 to the stylus, then click okay.

8. Next, identify the axes. Step 1: place the stylus at the origin (bottom right corner of the force plate). Press firmly downward into the force plate, and click the button. Make sure to stand behind the force plate during this process. Step 2: place the stylus 20 cm in the x-axis direction (forward), and press firmly into force plate then click the button. Step 3: place the stylus 20 cm in the y-axis direction (left), and press firmly into force plate then click the button.
Next, place the stylus anywhere above the force plate in line with the magnetic field box (blue), then click the button. Afterwards, the world axes setup will be complete.

9. Setup > Setup Force plates > “Gimble Height 0” > click okay. Attach sensor #5 to stylus > click okay > Step 1: Place stylus in position 1 of 3 > click button > Step 2: Place stylus in position 2 of 3 > click the button > Step 3: Place stylus in position 3 of 3 > click the button. Setup force plates should then be complete > click okay

10. Participant Preparation
   a. Select appropriate size shoe for participant. Make sure appropriate hole is cut out in shoe used for tested limb.
b. Place two pieces of Leukotape on heel. Place bare foot into shoe and have participant stand. Trace a box on tape through hole with sharpie. Remove foot and place a piece of double sided sticky tape on trace box of calcaneus. Place sensor #1 on sticky tape and anchor down with two pieces of Leukotape. Put sox back on over sensor and secure in the shoe.

c. Place a piece of double sided sticky tape on dorsal phalanx of shoe. Place sensor #2 on tape and anchor down with two pieces of Leukotape. Secure with Powerflex tape.

d. Place a piece of double sided sticky tape on mid lateral shank. Attach sensor #3, and anchor with two pieces of Leukotape.

e. While standing, use calf elastic Velcro wrap to anchor sensor 1-3 at the level of sensor #3.

f. Place a piece of double sided stick tape on mid lateral thigh. Attach sensor #4, and anchor with two pieces of Leukotape.

g. While standing, use thigh elastic Velcro wrap to secure sensors 1-4 at the level of sensor #4.
h. Place a piece of double sided sticky tape to the low back near L1 vertebrae. 
   Attach sensor #6, and secure with two pieces of Leukotape.
i. Finally use the largest elastic Velcro wrap to secure sensors 1-4, and 6 at the level 
   of sensor #6
j. Sensor #5 will remain attached to the stylus.
k. Finished Sensor Setup below for the right limb

11. Setup > Setup Subject Sensors > Make sure “Use force plates” and “use moveable 
    sensor” is selected in first two boxes > Click okay.
   a. Have participant place full body weight on force plate and stand still. Click Okay. 
      Select “Okay” if body weight seems correct. Then click okay to attach sensor #5 
      to stylus.
b. Place stylus on to of participant’s head. Click the button. Check to see if weight 
    seems correct.
c. Have subject remain still facing the x-axis and click the button
d. Place stylus on Left ASIS > click button
e. Place stylus on Right ASIS > click button
f. Hold still for final hip reading > click button
g. Click “okay” to accept hip joint locations
h. Place stylus on L5-S1 > click button
i. Place stylus on Left/Right Medial knee > click button
j. Place stylus on Left/Right Lateral knee > click button
k. Place stylus on Left/Right Medial ankle > click button
l. Place stylus on Left/Right Lateral ankle > click button
m. Place stylus on Left/Right tip of second phalanx > click button
n. Click “okay” to accept the joint locations
o. Participant Sensor Setup should be complete.
Participants then underwent three different conditions (FRT, Sham FRT, and no tape) and walked 10 separate trials under each condition. The FRT and Sham FRT were applied in the same manner, however the sham FRT had no tension placed on it. A picture below shows the FRT technique.

Sample Size Estimation

Based on previous evidence of external ankle taping on ankle sagittal plane gait kinematics in individuals with CAI, we calculated a sample size estimate with a 10% attrition rate to be 17 subjects total.
Procedural Methods

Informed Consent (n = 25)
Completed General Health History Form, FAAM Sport, IdFAI, and Godin Leisure-Time Exercise Questionnaires

Participant Sensor Setup and skeletal digitization (n = 20)

Did not meet criteria (n = 5)

Randomized to Cross Over Groups (single session)

Randomized Conditions:
1) FRT
2) Sham FRT
3) No Tape

Condition

10 Walking Trials

3X

Participants free to leave after completing 10 walking trials for each of the 3 conditions
Appendix D: Back Matter

Recommendations for future research

Future research should address whether a positional fault occurs due to lateral ankle sprains or if a positional fault is a predisposing factor to lateral ankle sprains. Additionally, further research is need to determine a valid and reliable method for evaluating a positional fault.
Effects of the Fibular Repositioning Taping on Lower Extremity Biomechanics during Gait in Active Adults with Chronic Ankle Instability

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Context: Individuals with chronic ankle instability (CAI) often present with impaired gait kinematics. Altered ankle arthrokinematics have been suggested to contribute to this poor movement pattern, with evidence identifying an anterior distal fibular position in CAI patients. Fibular reposition tape (FRT) is one intervention clinicians have utilized to address this anatomical fault of the distal fibula. However, the effect of FRT on lower extremity kinematics, kinetics or vertical ground reaction forces in individuals with CAI during gait has not been evaluated. Objective: To determine if an FRT application has any effect on ankle, knee, or hip kinematic, kinetics, and vertical ground reaction forces (vGRFs) during gait in individuals with CAI. Study Design: Cross over. Setting: Motion Analysis Laboratory Participants: Twenty active individuals with self-reported bilateral CAI (age=21.5±4.1 years, height=170.0±7.5cm, mass=81.8±22.0kg). Inclusion criteria consisted of a history of >1 ankle sprain, <85 on the Foot and Ankle Ability Measure Sport (FAAM), >11 on the Identification of Functional Instability Scale (IdFAI) and >24 on the Godin Leisure. Intervention: Participants received three conditions; FRT, sham FRT and no tape. Main Outcome Measurements: An electromagnetic three-dimensional motion capture system and imbedded force plate was used to collect lower extremity kinematics, kinetics and vGRF. Ten trials were completed for each of the three conditions. Data was reduced to 100 data points for the duration of a single gait cycle.
Curve analyses were used by plotting group means and 90% confidence intervals to compare differences between the sham FRT and no tape and then the FRT to the sham FRT. Significance was identified when confidence intervals did not overlap for three consecutive data points. **Results:** There were no significant differences when comparing no tape and sham FRT groups for all variables across the entire gait cycle. Additionally, there were no significant results when comparing the sham FRT and FRT groups for all variables across the entire gait cycle. **Conclusion:** Application of FRT did not have any effect on ankle, knee, or hip kinematics or kinetics across the entire gait cycle as well as vGRFs during the stance phase in individuals with CAI. While the application of FRT has produced improvements during balance and landing tasks, it did not influence gait kinematics or kinetics. Additional research should evaluate the potential underlying mechanism of FRT and its efficacy in the treatment of individuals with CAI.
Appendix F: Bibliography


