

**LOWER-LEG KINESIO® TAPE APPLICATION REDUCES RATE OF
LOADING IN SUBJECTS WITH MEDIAL TIBIAL STRESS SYNDROME**

by

Maggie Carson Griebert

A thesis submitted to the Faculty of the University of Delaware in partial
fulfillment of the requirements for the degree of Honors Bachelor of Science in
Athletic Training with Distinction

Spring 2012

© 2012 Maggie C. Griebert
All Rights Reserved

**LOWER-LEG KINESIO® TAPE APPLICATION REDUCES RATE OF
LOADING IN SUBJECTS WITH MEDIAL TIBIAL STRESS SYNDROME**

by

Maggie Carson Griebert

Approved: _____
Thomas W. Kaminski, Ph.D., ATC, FACSM, FNATA
Professor in charge of thesis on behalf of the Advisory Committee

Approved: _____
Alan R. Needle, MS, ATC, CSCS
Committee member from the Department of Kinesiology and Applied
Physiology

Approved: _____
Jennifer McConnell, Ph.D.
Committee member from the Board of Senior Thesis Readers

Approved: _____
Michael Arnold, Ph.D.
Director, University Honors Program

ACKNOWLEDGMENTS

I would like to thank my thesis advisors Dr. Thomas Kaminski and Alan Needle for their help and encouragement in the development and completion of this thesis. I would also like to thank my third reader, Dr. Jennifer McConnell and the faculty of the undergraduate research program, who also helped in this process.

I would also like to extend a thank you to the faculty and students of the University of Delaware Athletic Training Program for all of their support and encouragement throughout this year.

Finally, I would like to thank my family and friends for their continued love and support throughout this whole process. I couldn't have done it without them.

TABLE OF CONTENTS

LIST OF TABLES	3
LIST OF FIGURES	4
ABSTRACT	5
1 INTRODUCTION	6
2 METHODS	12
2.1 Design.....	12
2.2 Subjects.....	12
2.3 Procedures	13
2.4 Data Reduction and Analysis	15
3 RESULTS	18
4 DISCUSSION.....	22
5 CONCLUSION	26
REFERENCES	27
A INFORMED CONSENT FORM	31
B LOWER-LEG INJURY QUESTIONNAIRE	35

LIST OF TABLES

Table 1: Subjects' Demographics.....	12
Table 2: Mean TTPF in Healthy and MTSS Subjects (% Stance)	18

LIST OF FIGURES

Figure 1: Medial Tibial Stress Syndrome Location	6
Figure 2: Increased Pronation.....	8
Figure 3: Tekscan® Pressure Mat System	13
Figure 4: Kinesio® Tape Application	15
Figure 5: Averaged Stance Phase of Pressure Recording	16
Figure 6: Partitioned Foot Areas	17
Figure 5: Time-to-peak Force Before Tape Application	19
Figure 6: Time-to-peak Force of LFF in Healthy and MTSS Subjects	20
Figure 7: Time-to-peak force in the MMF in Healthy and MTSS Subjects	21

-

ABSTRACT

The purpose of this study was to determine if lower-leg Kinesio® taping has an effect on the rate of loading in subjects with medial tibial stress syndrome (MTSS). MTSS, commonly referred to as shin splints, is a common overuse injury that occurs in athletes. One of the major intrinsic risk factors of MTSS is an increase in pronation during the loading phase of gait. This study tested the effect of Kinesio® tape on rate of loading during gait in 20 healthy control subjects and 20 subjects with a history of MTSS. Subjects walked across a Tekscan® plantar pressure mat under 3 conditions: prior to tape application, immediately after tape application and after wearing the tape for 24-hours. Time-to-peak force (TTPF) measurements were recorded to measure rate of loading and compared between groups and across the three conditions in six areas of the foot using an analysis of variance. There was a significant interaction effect between group, condition, and foot area ($F = 1.990$, $p = 0.033$). Healthy subjects showed significantly higher TTPF values in the medial midfoot before tape application ($p = 0.021$) and MTSS subjects showed a significant increase in TTPF with tape application for the medial midfoot and lateral forefoot ($p = 0.022$, $p = 0.043$, $p = 0.031$). Our results suggest that Kinesio® tape use may decrease the rate of loading in subjects with MTSS. This may be clinically significant in helping with the treatment of MTSS. Future research should assess how muscle activity is altered by tape use.

Chapter 1

INTRODUCTION

Medial tibial stress syndrome (MTSS), commonly referred to as shin splints, is one of the most prevalent causes of exercise-induced leg pain in athletes (4). Research estimates that MTSS contributes to 13-17% of all running injuries (25, 39), and 4-35% of all cases of exercise-related leg pain (22). This condition is characterized by pain along the posteromedial aspect of the distal two-thirds of the tibia (Figure 1) that occurs prior to, during, or after activity (22, 37).

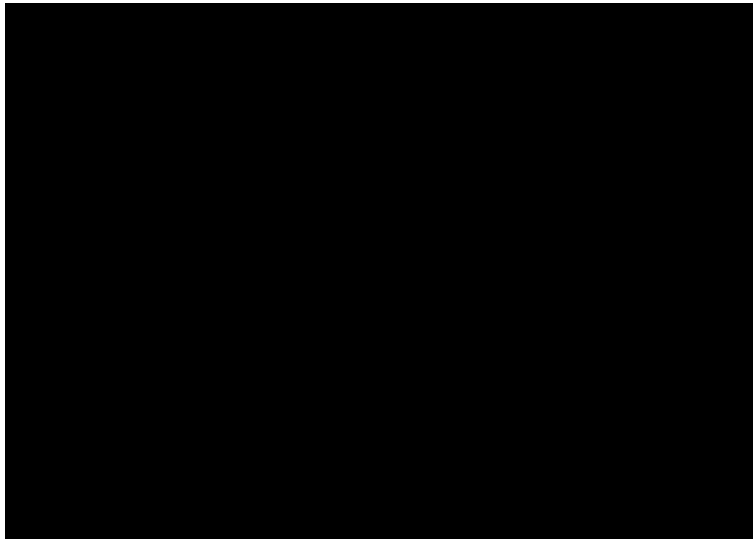


Figure 1: Medial Tibial Stress Syndrome Location
(http://www.hughston.com/hha/a_13_4_6.htm)

To distinguish it from other similar pathologies such as, tibialis anterior or tibialis posterior tendinitis, periostitis (9, 23, 33), bone stress reactions (3, 17), tibial stress

fractures, (26) and exertional compartment syndrome (12), Yates et al. (39) provided specific diagnostic criteria including pain induced by exercise, lasting for a few hours or days after cessation of activity, tenderness in an area greater than 5 cm eliciting discomfort and possible palpable deformities of the bone (39). The progression of MTSS can lead to further complications that affect athletic performance and may be linked to pathologies at the foot, knee, and hip joints. Although related to many other causes of exercise-induced leg pain, it remains unclear why this condition develops compared to others.

Various risk factors for MTSS have been identified including changes in type, duration or frequency of activity; changes in or improper footwear; and type of running surface (4, 37, 39). While these extrinsic factors are alterable, a number of non-modifiable intrinsic factors are also present. These include a positive navicular drop test during static standing and increased pronation during the loading response of the gait cycle (2, 5, 11, 21, 31, 39), biomechanical alterations in running gait (34), higher body mass index (BMI) (25), female gender (5, 6, 39), lean calf girth (6), and increased plantar flexion range of motion (15, 21). Among these, the highest levels of evidence exist supporting a positive navicular drop test and increased foot pronation during gait as observed in multiple studies on large numbers of military recruits (22, 39), recreational athletes and runners (2, 7, 8, 34, 36, 37), dancers (31), collegiate athletes (15, 27) and high school athletes (5, 11), where subjects with increased pronation were twice as likely to develop medial tibial stress syndrome (Figure 2).

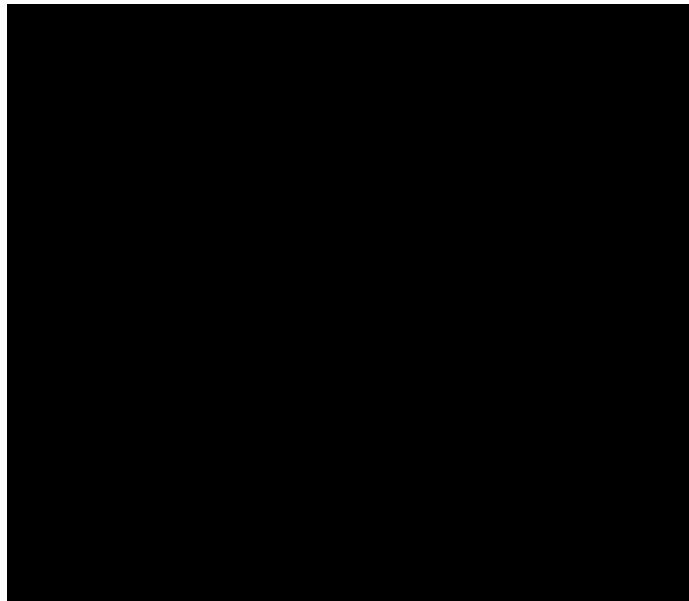


Figure 2: Increased Pronation – A positive navicular drop test is a diagnostic test in which the height of the bone at the apex of the medial longitudinal arch of the foot is measured during weight-bearing and non-weight-bearing and differs more than 10mm suggesting hyperpronation of the foot. (<http://www.dubinchiro.com/features/shin1.html>)

This increase in pronation, possibly due to varus alignment of the rearfoot or forefoot, has been hypothesized to increase the stress on the deep plantar flexors and invertors that may be aggravated in patients with MTSS.

One way to quantify alterations in pronation during gait is through measurements of the plantar pressure placed on the foot. Previous research has demonstrated significant increases in medial plantar pressures in subjects with exercise-induced leg pain, although its relative contribution to MTSS specifically has not been assessed (29, 37). Sharma et al. studied risk factors for MTSS in military recruits and found higher rearfoot peak plantar pressures during running present in 70% of the recruits who developed MTSS, while only 14% of their healthy control

group had similar plantar pressure measurements (29). Although these previous studies have not examined rate of loading, the increases in peak plantar pressures of the medial midfoot and rearfoot may suggest that there is an increased rate of loading of plantar pressures and poor biomechanical patterns present. Both of these factors may also be a risk factors in the development of MTSS and must be taken into consideration when developing prevention and treatment programs

In order to relieve symptoms related to MTSS, clinicians have used various rehabilitation techniques and modalities in conjunction with taping and bracing. Several modalities, such as the use of non-steroidal anti-inflammatories (1), massage (18), therapeutic laser and ultrasound (24), and ice (1), have been used with limited effectiveness. Research has suggested the need to change mechanics through strengthening, but taping and orthotics may also provide relief and correct poor biomechanics, such that the recurrence of symptoms may be limited. Some research have also investigated the effectiveness of therapeutic interventions such as the use of immobilization (24), compression sleeves and tapings (18), orthotics for shock absorption and pronation control (10, 28), and calf muscle strengthening and flexibility (1, 18). Although these interventions and treatments may be effective if used in conjunction with each other, there were no significant findings to support their individual usage. The only treatment that has consistently proven to be effective is cessation from activity (22).

Recently, Kinesio® taping has garnered interest among sports medicine clinicians for treating a variety of musculoskeletal pathologies. Developed in the

1970s by Dr. Kenso Kase, Kinesio® tape is an elastic therapeutic tape used intended primarily for the treatment of sport-related injuries (32). The tape is designed to mimic the properties of skin in its thickness and elasticity; while differing from traditional athletic tape in several ways, including tensile strength and flexibility, as well as the binding agents; which together allow the tape to be worn for several days at a time. Although there has been some research performed using Kinesio® tape, very few of these studies have investigated its use for sports-related injuries. A recent meta-analysis of ten studies on Kinesio® taping observed that Kinesio® taping may have a beneficial effect on strength, force sense error and active range of motion of an injured area, however no significant findings were found to support improvements in pain, ankle proprioception or muscle activity (38). Of the ten studies discussed, only two studied the effects of Kinesio® tape on injured populations, neither of which involved the lower extremity (38). Additionally, there were very few who examined the effect on the alteration of the biomechanical patterns of movement; some used electromyography (EMG, a technique used to measure electrical activity of muscles) to measure muscle activation and strength (16, 30), isokinetic dynamometers and cybex machines (13, 35), and one used an instrumented platform to measure joint position sense (14).

As the use of Kinesio® taping becomes more widespread among sports medicine and orthopedic clinicians, further investigation is warranted into the efficacy of this tape on musculoskeletal pathologies. The purpose of this research is to examine the effects of Kinesio® taping on plantar pressure in subjects with a history of MTSS.

We hypothesize that the Kinesio® tape will cause a decrease in time-to-peak force in the medial foot, which is commonly associated with MTSS.

Chapter 2

METHODS

2.1 Design

A pre-test post-test study design with a control group was used to measure changes in time-to-peak force in subjects before and after Kinesio® tape application. Independent variables included group (MTSS subjects vs. healthy controls) and tape application. Dependent variables included time-to-peak force in six areas of the foot (refer to section 2.4).

2.2 Subjects

Forty subjects volunteered for this study. The sample included 20 healthy subjects (10 M, 10 F, 173.2 ± 11.7 cm, 76.9 ± 14.4 kg, 20.2 ± 1.5 yrs.) and 20 subjects with a previous or current history of MTSS (10 M, 10F, 172.7 ± 10.4 cm, 74.3 ± 13.4 kg, 20.7 ± 2.0 yrs.) (Table 1). All subjects were recruited from a university community and provided institution-reviewed informed consent (UDIRB 247899-1) (Appendix A).

Table 1: Subjects' Demographics

	Gender	Age (years)		Height (cm)		Mass (kg)	
		Mean	SD	Mean	SD	Mean	SD
Healthy	10 M, 10 F	20.2	1.5	173.2	11.7	76.9	14.4
MTSS	10 M, 10mF	20.7	2.0	172.7	10.4	74.3	13.4

Subjects were stratified using a lower-leg injury questionnaire (Appendix B) adapted from Hubbard et al. (15), which included inclusion criteria for the subjects in MTSS group. Subjects with no previous history of MTSS and no lower limb injuries within the past 6 months were classified as healthy; while subjects who had a current or previous history of MTSS that was either diagnosed by a physician or healthcare professional, with no other lower limb injuries within the past 6 months were placed in the MTSS group. The rationale for grouping MTSS subjects with current and previous history of MTSS in the same category is discover if there is biomechanical difference that predisposes these subjects for development of MTSS.

2.3 Procedures

Plantar pressures were measured using a 442mm x 488mm Tekscan® (Tekscan, Boston, MA) (Figure 1) pressure mat system. Prior to testing, the mat was calibrated based on the subject's mass for each individual using the calibration system in the Tekscan® software.



Figure 3: Tekscan® Pressure Mat System

In healthy subjects, the test leg was determined randomly through a coin toss. In the subjects with MTSS, the test leg was determined by which leg was affected by MTSS or, in the presence of bilateral injury, which leg presented worse symptoms.

Once calibration was completed the individual was asked to walk across the plantar pressure mat under three different conditions: prior to tape application (PRE), immediately following tape application (KT-I), and after 24-hours of continued use (KT-24). Between KT-I and KT-24 trials, subjects were allowed to continue normal activities of daily living, including showering, with the tape in place. Subjects then walked at a self-selected speed across the mat 5 times using the 2-step gait initiation method (40), ensuring the test leg landed on the mat and that they started the same distance away from the mat each time, as marked by a pre-measured line. The 2-step gait initiation method involves landing on the pressure mat on the second step after a constant velocity has been reached and then continuing to walk through the mat for 2 steps. This method was used because it has been shown to reproduce plantar pressures and forces that are present during normal gait (40). Two practice trials for each condition were provided and a rest period of 5-10 seconds was provided between each trial. Trials were rejected if the subject's gait was noticeably altered so that the test leg would contact the mat.

The taping technique used for this study was a modification of the MTSS technique as outlined by Kenzo Kase (20). Prior to Kinesio® tape application, hair was removed from the medial tibia and the area was cleaned with an alcohol swab. Tape adherent (Cramer Tuf-Skin®, Gardner, KS) was applied to the area to improve the adhesiveness of the tape. A single Y-strip was applied beginning with the tail placed on the proximal third of the medial tibia. Each half of the Y-strip was then

applied so that they lay anterior and posterior to the medial malleolus and terminated under the medial longitudinal arch of the foot. No tension was applied on the proximal and distal ends of the tape, while the remainder of the tape was applied with 75% tension (Figure 4).

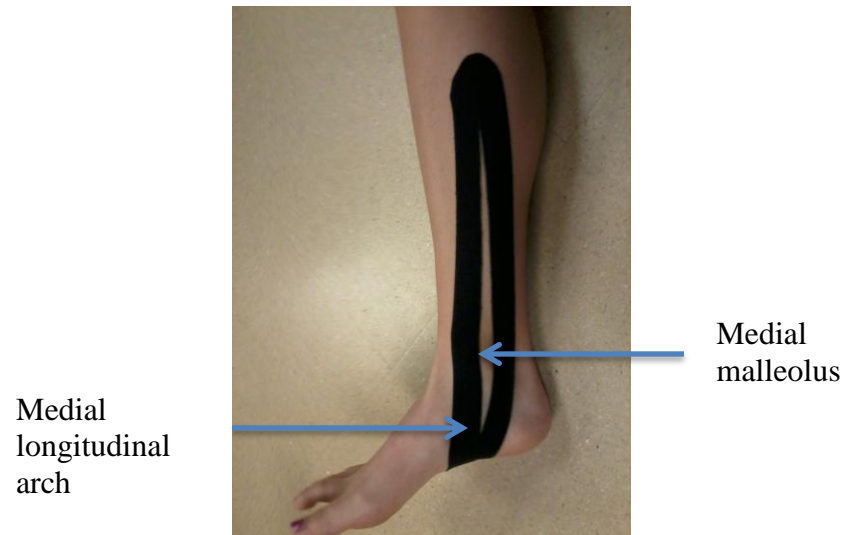


Figure 4: Kinesio® tape application

2.4 Data Reduction and Analysis

Continuous data were collected during each trial using the F-Scan® System Research software (Tekscan, Boston, MA). The averaged stance phase of gait, the period of gait in which the foot is in contact with the pressure mat, was viewed for each of the trials (Figure 5).

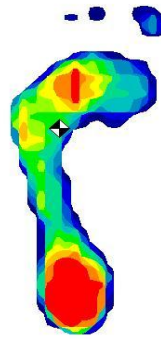


Figure 5: Averaged Stance Phase of Pressure Recording

*Plantar pressures are shown with red being the highest and blue being the lowest.

Each of the files was then partitioned into six foot areas: lateral forefoot (LFF), medial forefoot (MFF), lateral midfoot (LMF), medial midfoot (MMF), lateral rearfoot (LRF), and medial rearfoot (MRF). This division of the foot was created manually using the F-Scan® System Research software. The division of lateral and medial components of the foot was determined by using a straight line to bisect the space between the second and third metatarsals through the foot to the midpoint of the calcaneus. The forefoot and midfoot were separated by the center of the metatarsal heads. The midfoot and rearfoot were then separated by the distal aspect of the calcaneus (Figure 6).

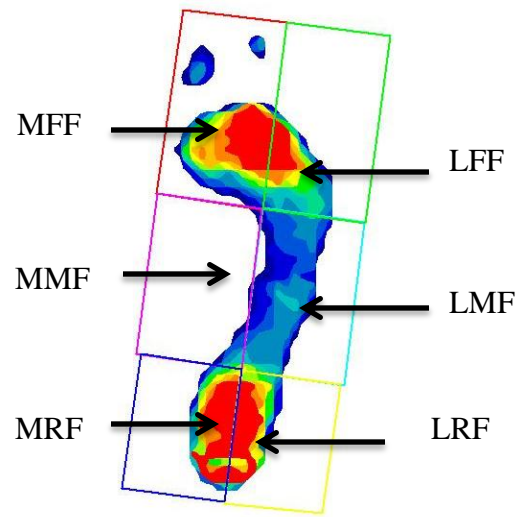


Figure 6: Partitioned Foot Areas

Time-to-peak force (TTPF) in each foot area was then exported and further analyzed in Custom LabVIEW software (National Instruments, Austin, TX). Time-to-peak force was normalized to the length of the stance phase because TTPF is measured as a percentage of the total stance time.

Data were analyzed using SPSS 17.0 (IBM, Chicago, IL). Three-way analyses of variance (ANOVA's) with one between-subjects factor (Group, 2 levels), and two within-subjects factors (Tape Condition, 3 levels; Foot Area, 6 levels) was used to detect significant differences for TTPF. In the case of significant interaction, pairwise comparisons were used to detect where differences occurred. A level of significance (α) of 0.05 was set *a priori*.

Chapter 3

RESULTS

Time-to-peak force results from the gait trials are presented in Table 2. A 3-way ANOVA revealed a significant interaction effect for condition, foot area and group ($F = 1.990$, $p = 0.033$). Pairwise comparisons revealed significant differences between groups in the MMF before tape application (PRE) ($p = 0.021$), where healthy subjects had higher TTPF under the MMF than MTSS subjects (Figure 5). No other areas of the foot were significantly different at PRE. There were also no significant differences between groups under MMF during KT-I and KT-24 ($p = 0.054$, $p = 0.018$).

Table 2: Mean TTPF in Healthy and MTSS Subjects (% Stance)

Condition	NT		KT-I		KT-24	
Foot Area	Healthy	MTSS	Healthy	MTSS	Healthy	MTSS
LFF	0.693 ± 0.06	0.670 ± 0.07	0.698 ± 0.04	0.695 ± 0.06	0.695 ± 0.05	0.685 ± 0.06
LMF	0.392 ± 0.11	0.418 ± 0.07	0.401 ± 0.08	0.415 ± 0.10	0.404 ± 0.12	0.419 ± 0.09
LRF	0.172 ± 0.04	0.181 ± 0.04	0.176 ± 0.04	0.172 ± 0.05	0.182 ± 0.03	0.169 ± 0.05
MFF	0.741 ± 0.04	0.746 ± 0.05	0.748 ± 0.02	0.750 ± 0.03	0.750 ± 0.02	0.750 ± 0.02
MMF	0.329 ± 0.08	0.242 ± 0.14	0.319 ± 0.12	0.298 ± 0.10	0.333 ± 0.10	0.287 ± 0.12
MRF	0.173 ± 0.04	0.173 ± 0.03	0.182 ± 0.04	0.171 ± 0.05	0.179 ± 0.03	0.174 ± 0.04

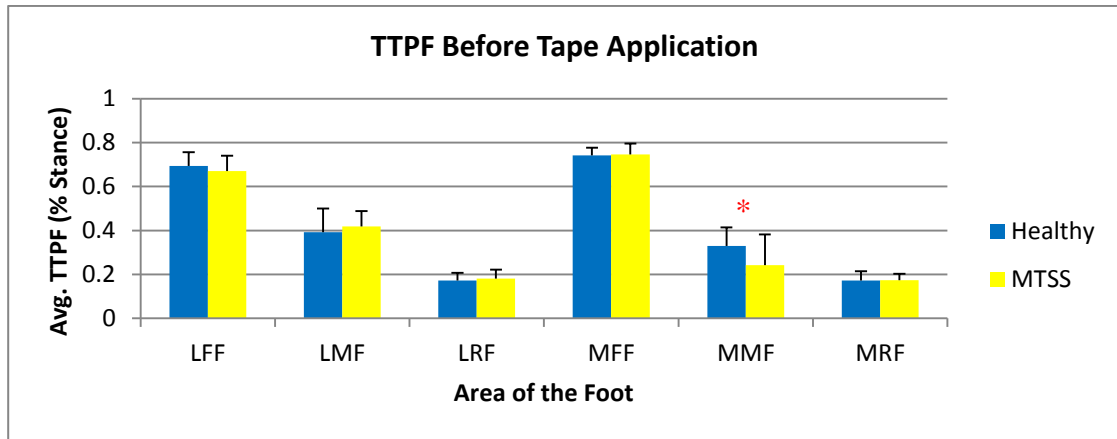


Figure 5: Time-to-peak force before tape application. *A significant interaction between groups exhibited under MMF.

Within the MTSS group, significant improvements were observed from PRE to KT-I under the LFF ($p = 0.031$,) (Figure 6). There was no significant difference between the other conditions ($p = 0.220$, $p = 0.290$).

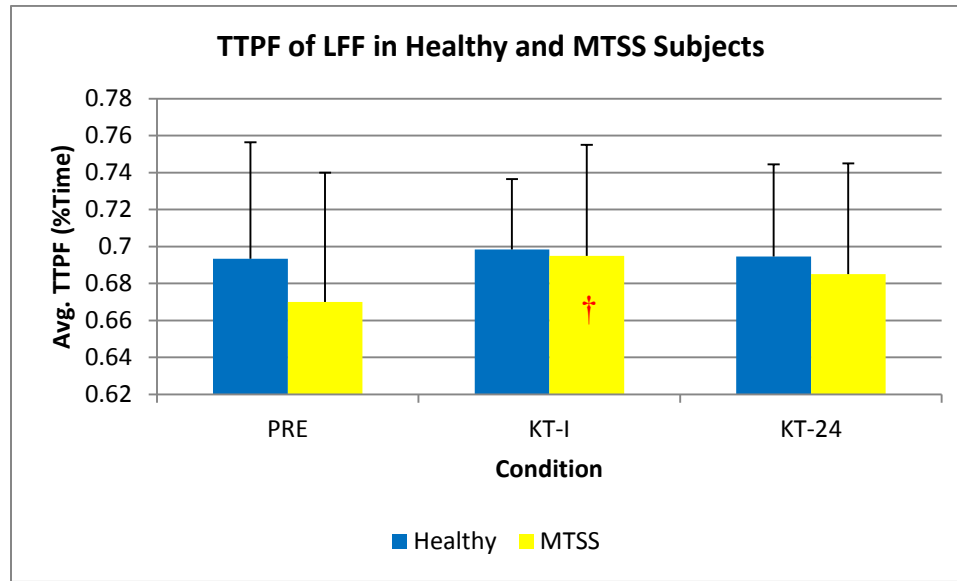


Figure 6: Time-to-peak force of LFF in healthy and MTSS subjects. †A significant condition interaction between MTSS subjects from PRE to KT-I.

Furthermore, in the MMF there was a significant difference from PRE to KT-I ($p = 0.022$) where TTPF was lower in PRE (Figure 7). There was also a significant difference between PRE and KT-24 ($p = 0.043$), where TTPF was lower in PRE. This demonstrates that TTPF increased under the MMF with application of the Kinesio® tape, indicating a decrease in the rate of loading under the MMF and LFF in subjects with MTSS.

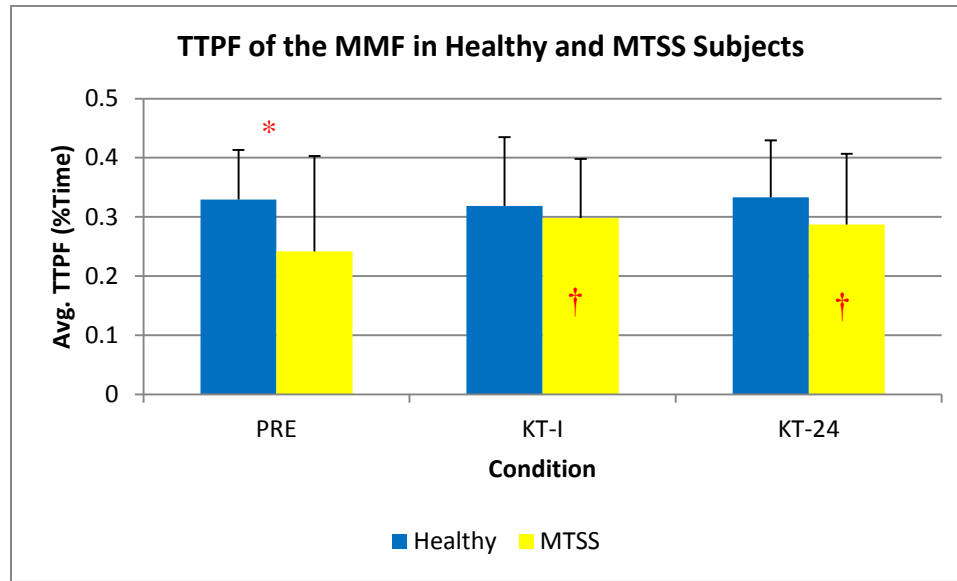


Figure 7: Time-to-peak force in the MMF in Healthy and MTSS Subjects. †A significant condition interaction of MMF between PRE, KT-I and KT-24 for subjects with MTSS. *A significant between groups interaction.

Chapter 4

DISCUSSION

The purpose of this study was to investigate the effect of lower-leg Kinesio® taping on plantar pressures in subjects with medial tibial stress syndrome. We hypothesized that the Kinesio® tape would cause a decrease in excessive medial rate of loading associated with MTSS. There was a significant difference between healthy and MTSS subjects before tape application in the medial midfoot. The overall findings of this study support our hypothesis, showing a significant effect of application of Kinesio® tape on TTPF of the medial midfoot.

The difference between groups before tape application suggests that there is an initial biomechanical difference between the two groups. This demonstrates that the rate of loading in the medial foot may be a contributing risk factor towards the etiology of MTSS. The MTSS groups had a lower TTPF than the healthy subjects under the MMF, indicating a higher rate of loading in subjects with MTSS. This finding shows that the MTSS subjects had a faster rate of pronation during the stance phase of gait. The reason TTPF can be related to the rate of pronation of the foot is because the purpose of pronation is to get the MMF and MFF to contact the ground. These data demonstrate that the difference between the groups before tape applications represents a biomechanical difference between people with a history of MTSS that may predispose them for this injury or develop as a result of this injury.

The difference between groups is also consistent with previous research on the causes of MTSS, where foot pronation has been identified as a risk factor. Several

previous studies have linked excessive foot pronation as a risk factor for MTSS. According to previous studies, subjects who had excessive pronation during the loading phase of the gait cycle were twice as likely to develop MTSS (2, 5, 11, 22, 31, 39). Our findings also show that subjects with MTSS exhibit this same pattern of an increased rate of pronation during gait. By increasing the rate of pronation, this movement causes increased strain on the tibialis posterior tendon which is one of the primary muscles that is involved in pronation of the foot. This muscle's attachment along the medial tibia contributes to the stress placed on the tibia due to constantly being strained during pronation. Our findings are unique because we used TTPF to measure rate of loading in different areas of the foot. Previous studies focused more on joint angles, anatomical alignments and plantar pressures, which do not take into account how the person pronates during a functional movement. The measurement of TTPF is a better representation of an increased rate of pronation because it takes into account the entire stance phase of gait.

The other significant finding from our study was the significant effect that Kinesio® tape had on TTPF on the lateral forefoot and medial midfoot in subjects with MTSS. After tape application, there was an increase in TTPF in both the lateral forefoot and medial midfoot indicating a decreased rate of loading in both of these foot areas. This means that the rate of pronation was decreased with application of the tape. This same effect was not significant in healthy subjects, possibly because normal TTPF could not be improved upon.

Although there are no previous studies that have looked at the use of Kinesio® tape for medial tibial stress syndrome, previous studies using Kinesio® tape have shown that this tape has some possible benefits. It has been reported that there is a

small beneficial effect on strength, force sense error and active range of motion, but no significant effect in improving pain, ankle proprioception or muscle activity (38). In particular, these previous studies showed an improvement in shoulder kinematics and range of motion with tape application (16, 32). Even though these findings cannot be generalized to other joints, these studies also support that Kinesio® tape has a mechanical effect on a joint's biomechanics. The specific taping that we used in this study is speculated to have caused a change in the rate of loading of the medial foot due to a proprioceptive effect which increases pre-activation of the muscles. This means that before the person contacts the ground, the muscles of the leg, specifically those controlling foot pronation and supination, are activated so that excessive of pronation is controlled during gait.

The findings from our study are clinically significant because of the possibility of integrating Kinesio® taping for the lower-leg in the management and treatment of medial tibial stress syndrome. The use of this tape in people with MTSS may help correct an excessive rate of pronation, which our data, as well as previous studies, support as a risk factor and cause of MTSS. By helping to correct the rate of pronation during gait, this may correlate with the same corrections in running and other sport activity. The change in the rate of pronation may also result in a relief of the pain and other symptoms of MTSS with prolonged use when used in conjunction with other rehabilitation techniques, which were shown to be unsuccessful when used individually (1, 10, 18, 22, 24, 28).

This current study has a few limitations. First, the subjects included in this study were a generalized group of physically active people. These subjects could have been further narrowed by including athletes from specific sports because each sport

places different stresses on the body, specifically regarding jumping vs. running. Additionally, there was no control for the amount of activity performed between testing sessions KT-I and KT-24. In future studies, this should be controlled because it may alter the results recorded from KT-24. There is also no way to determine how muscle activity was altered through use of the tape. Continued research should be conducted to determine if application of this tape changes the activity in the muscles that control foot pronation. Future research may also compare more traditional taping techniques for MTSS and arch tapings along with other therapeutic techniques to this method of Kinesio® taping. Although it is difficult to quantify relief of symptoms of medial tibial stress syndrome with our study, a future randomized controlled study could be the next step to determine how the use of Kinesio® tape affects symptoms as compared to these other treatments. This could better aid in determining how the use of Kinesio® tape can be integrated in treatment of MTSS.

Chapter 5

CONCLUSION

Our findings demonstrate that Kinesio® tape for the lower-leg may be beneficial in minimizing rate of medial loading of the foot in people with MTSS. We postulate that this decreased rate of pronation may be beneficial for reducing injurious forces in people suffering from MTSS during activity. The difference between groups in TTPF is consistent with previous studies on MTSS that show that excessive pronation is a major risk factor in the development of MTSS. The use of the TTPF measurement is unique and significant because it shows a change in the rate of pronation throughout the entire stance phase of gait, as opposed to a static measurement. Additionally, the effect of Kinesio® tape on increasing TTPF in MTSS subjects provides support that Kinesio® tape may have some proprioceptive effect on joint activity. Although we did not quantify relief of symptoms with tape application, future studies may look into how application of this tape aids in the management of MTSS.

REFERENCES

1. Andrish, J. T., Bergfeld, J. A., & Walheim, J. (1974). A prospective study of the management of shin splints. *Journal of Bone and Joint Surgery, American Volume* (56), 1697-1700.
2. Bandholm, T., Boysen, L., Haugaard, S., Kreutzfeldt Zebbs, M., & Bencke, J. (2008). Foot medial longitudinal-arch deformation during quiet standing and gait in subjects with medial tibial stress syndrome. *The Journal of Foot & Ankle Surgery*, 47(2), 89-95.
3. Batt, M. E., Ugalde, V., Anderson, M. W., & Shelton, D. K. (1998). A prospective controlled study of diagnostic imaging for acute shin splints. *Medicine & Science in Sports & Exercise*, 30(11), 1564-1571.
4. Beck, B. R. (1998). Tibial stress injuries: An aetiological review for the purposes of guiding management. *Sports Medicine*, 26(4), 265-279. doi:0112-1642/98/0010-0265
5. Bennett, J. E., Reinking, M. F., Pleumer, B., Pentel, A., Seaton, M., & Killian, c. (2001). Factors contributing to the development of medial tibial stress syndrome in high school runners. *Journal of Orthopaedic & Sports Physical Therapy*, 31(9), 504-510.
6. Burne, S. G., Khan, K. M., & Boudville, P. B. (2004). Risk factors associated with exertional tibial pain: A twelve months prospective clinical study. *British Journal of Sports Medicine*, 38(4), 441-445.
7. Busseuil, C., Freychat, P., Guedj, E. B., & Lacour, J. R. (1998). Rearfoot-forefoot orientation and traumatic risk for runners. *Foot & Ankle International*, 19, 32-37.
8. Caborn, D. N. M., Grollman, L. J., Nyland, J. A., & Brosky, T. (1994). Running: Evaluation and treatment of the injured runner. In F. H. Fu, & D. A. Stone (Eds.), *Sports injuries: Mechanisms, prevention, and treatment* (pp. 565-589). Baltimore, Maryland: Williams and Wilkins.
9. Clement, D. B. (1974). Tibial stress syndrome in athletes. *Journal of Sports Medicine*, 2(2), 81-85.

10. Craig, D. I. (2008). Medial tibial stress syndrome: Evidence-based prevention. *Journal of Athletic Training*, 43(3), 316-318.
11. Delacerda, F. G. (1980). A study of anatomical factors involved in shin splints. *Journal of Orthopaedic & Sports Physical Therapy*, 2(2), 55-59.
12. Devas, M. B. (40B). Stress fractures of the tibia in athletes or "shin soreness". *The Journal of Bone and Ankle Surgery*, 2(1958), 227-239.
13. Fu, T., Wong, A. M. K., & Pei, Y. (2008). Effect of kinesio taping on muscle strength in athletes: A pilot study. *Journal of Sports Science and Medicine*, 11(2), 198-201.
14. Halseth, T., McChesney, J. W., & DeBeliso, M. (2004). The effects of kinesio taping on proprioception at the ankle. *Journal of Sports Science and Medicine*, 3(1), 1-7.
15. Hubbard, T. J., Mullis Carpenter, E., & Cordova, M. L. (2009). Contributing factor to medial tibial stress syndrome: A prospective investigation. *Medicine & Science in Sports & Exercise*, 41(3), 490-496.
16. Hsu, Y. H., Chen, W. Y., & Lin, H. C. (2009). The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. *Journal of Electromyography and Kinesiology*, 19(6), 1092-1099.
17. Johnell, O., Rausing, A., Wendeberg, B., & Westlin, N. (1982). Morphological bone changes in shin splints. *Clinical Orthopaedics and Related Research*, 167, 180-184.
18. Johnston, E., Flynn, T., & Bean, M. (2006). A randomised controlled trial of a leg orthosis versus traditional treatment for soldiers with shin splints: A pilot study. *Military Medicine*, 171(1), 40-44.
19. Kase, K., Hashimoto, T., & Tomoki, O. (1996). Development of Kinesio® taping perfect manual. *Kinesio® Taping Association*. 6(10), 117-118.
20. Kase, K., Wallis, J., & Kase, T. (2003). *Clinical therapeutic applications of the Kinesio taping method*. Albuquerque, NM: Kinesio® Taping Association.

21. Moen, M. H., Bongers, T., Bakker, E. W., Zimmermann, W. O., Weir, A., Tol, J. L., & Backx, F. J. G. (2010). Risk factors and prognostic indicators for medial tibial stress syndrome. *Scandinavian Journal of Medicine & Science in Sports*, 22, 34-39.
22. Moen, M. H., Tol, J. L., Weir, A., Steunebrink, M., & De Winter, T. C. (2009). Medial tibial stress syndrome: A critical review. *Sports Medicine*, 39(7), 523-546.
23. Mubarak, S. J., Gould, R. N., Lee, Y. F., Schmidt, D. A., & Hargens, A. R. (1982). The medial tibial stress syndrome: A cause of shin splints. *American Journal of Sports Medicine*, 10(4), 201-205.
24. Nissen, L. R., Astvad, K., & Madsen, L. (1994). Low-energy laser treatment of medial tibial stress syndrome. *Ugeskr Laeger*, 156(49), 7329-7331.
25. Plisky, M. S., Rauh, M. J., Heiderscheit, B., Underwood, F. B., & Tank, R. T. (2007). Medial tibial stress syndrome in high school cross-country runners incidence and risk factors. *The Journal of Orthopaedic & Sports Physical Therapy*, 37(2), 40-47.
26. Puranen, J., & Alavaikko, A. (1981). Intracompartmental pressure increase on exertion in patients with chronic compartment syndrome in the leg. *The Journal of Bone and Joint Surgery*, 63(8), 1304-1309.
27. Reinking, M. F. (2006). Exercise-related leg pain in female collegiate athletes: The influence of Intrinsic and extrinsic factors. *American Journal of Sports Medicine*, 34(9), 1500-1507.
28. Rome, K., Handoll, H.H.G, & Ashford, R.L. (2005). Interventions for preventing and treating stress fractures and stress reactions of bone of the lower limbs in young adults. *Cochrane Database of Systematic Reviews*, 2, 1-49.
29. Sharma, J., Golby, J., Greeves, J., & Spears, I. R. (2011). Biomechanical and lifestyle risk factors for medial tibia stress syndrome in army recruits: A prospective study. *Gait & Posture*, 33, 361-365.
30. Słupik, A., & Dwornik, M. (2007). Effect of kinesio taping on bioelectrical activity of vastus medialis muscle. preliminary report. *Ortopedia Traumatologia Rehabilitacja*, 9(6), 644-651.

31. Sommer, H. M., & Vallentyne, S. W. (1995). Effect of foot posture on the incidence of medial tibial stress syndrome. *Medicine & Science in Sports & Exercise*, 27(6), 800-804.
32. Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of kinesio tape for shoulder pain: A randomized double-blinded, clinical trial. *Journal of Orthopaedic & Sports Physical Therapy*, 38(7), 389-395.
33. Touliopolous, S., & Hershman, E. B. (1999). Lower-leg pain: Diagnosis and treatment of compartment syndromes and other pain syndromes of the leg. *Sports Medicine*, 27(3), 193-204.
34. Tweed, J. L., Avil, S. J., & Campbell, J. A. (2008). Biomechanical risk factors in the development of medial tibial stress syndrome in distance runners. *Journal of the American Podiatric Medical Association*, 98(6), 436-444.
35. Vithoulka, I., Beneka, A., & Malliou, P. (2010). The effects of kinesio-taping on quadriceps strength during isokinetic exercise in healthy non athlete women. *Isokinetics and Exercise Science*, 18(1), 1-6.
36. Viitasalo, J. K., & Kvist, M. (1983). Some biomechanical aspects of the foot and ankle in athletes with and without shin splints. *American Journal of Sports Medicine*, 11(3), 125-130.
37. Willems, T. M., De Clercq, D., Delbaere, K., Vanderstraeten, G., De Cock, A., & Witvrouw, E. (2006). A prospective study of gait related risk factors for exercise-related lower-leg pain. *Gait & Posture*, 23(1), 91-98.
38. Williams, S., Whatman, C., Hume, P.A., & Sheerin, K. (2012). Kinesio® Taping in Treatment and Prevention of Sports Injuries: A Meta-Analysis of the Evidence for its Effectiveness. *Sports Medicine*, 42(2), 153-164.
39. Yates, B., & White, S. (2004). The incidence and risk factors in the development of medial tibial stress syndrome among naval recruits. *The American Journal of Sports Medicine*, 32(3), 772-780.
40. Zammit, G.V., Menz, H.B., & Munteanu, S.E. (2010). Reliability of the TekScan MatScan system for the measurement of plantar forces and pressures during barefoot level walking in healthy adults. *Journal of Foot and Ankle Research*, 3(11), 1-9.

Appendix A

INFORMED CONSENT FORM

RESEARCH STUDY: Lower-leg Kinesio® Tape Application Reduces Rate of Loading in Subjects with Medial Tibial Stress Syndrome

INVESTIGATORS: Maggie Griebert
Alan R. Needle, MS, ATC, CSCS
Thomas W. Kaminski, PhD, ATC, FNATA, FACSM

SUBJECT NAME: _____

1. PURPOSE / DESCRIPTION OF THE RESEARCH

You are being asked to participate in a research study conducted at the University of Delaware. The purpose of this research study is to determine the effectiveness of Kinesio Tape® on reducing foot pressure in people with medial tibial stress syndrome or shin splints. Shin splints are defined as pain on the inside of the lower-leg usually due to overuse. Foot pressure is defined as the amount of pressure exerted on parts of the foot when a person is standing walking or running. Increased foot pressure is common symptom and cause of shin splints. This study will measure the plantar pressure in healthy subjects and in those with shin splints or a history of shin splints before and after the application of Kinesio Tape®.

Kinesio Tape® is a type of athletic tape that has become more popular in recent years. It is designed to mimic skin in its thickness and elastic properties. It is different from traditional athletic tape because it is much stronger, more flexible and stretches more than the traditional white tape. It is also applied directly to the skin, while athletic tape is often applied over a layer of pre-wrap or a soft non-adhesive layer to prevent irritation.

You will be 1 of 40 subjects (20 men and 20 women) between the ages of 18 and 40 years old that will be recruited for this study. All subjects recruited will either have no history of shin splints or have had a history of shin splints. Full participation will require two consecutive visits to the laboratory. The first 60 minute visit will require you to fill out a questionnaire which will ask for a brief medical and injury history and this will be followed by the testing session. You will be required to wear the tape for approximately 24 hours until the second visit. The second 30 minute visit will consist of the same testing as the previous day. You will also be provided with an explanation of this document and a full explanation of the research project.

Testing consists of three parts: the first two parts will be completed on the first day and the final part will be completed on the second day. After filling out all required paperwork, the pressure mat will be calibrated for you individually by having you stand on it. Then the first part of testing will consist of standing still on the pressure mat five times on your left foot followed by five times on your right foot for 10 seconds. Then you will be asked to walk across the pressure mat ten times. After this baseline testing, the Kinesio Tape® will be applied to your skin. This will require making sure your skin is clean using an alcohol swab and shaving of hair if necessary. The tape will then be applied to your lower-leg and foot. Once the tape has been applied, you will be asked to perform the same testing as before. You will then be instructed to keep the tape on for 24 hours and will return the next day to perform the same tests once again. Once the testing is complete on the second day, you will be able to remove the tape.

2. CONFIDENTIALITY

Information obtained from this study will be kept strictly confidential. You will not be individually identified, except by a subject number that is known only to the investigators. All data stored as paper filed or on computer disk will be kept in a locked cabinet for at least three years. The data stored on the computer will be password protected. After three years your data files will be archived, but all personal identifiers will be destroyed. While the results of this

research may be published and presented at conferences, your name or identity will not be revealed.

3. CONDITIONS OF SUBJECT PARTICIPATION

You will be excluded from participation if you have any neural, orthopedic, or general medical condition that will affect the accuracy of these tests. This includes any history of significant injury to the leg within the past 6 months, any history of ankle or lower-leg surgery, or if you have a current foot or ankle injury. Significant injury is defined as an injury requiring immobilization and/or a visit to a physician. You will also be excluded from this study if you have any allergies to band-aids or tape.

4. RISKS AND BENEFITS

There are no significant risks for participating in this study, except for some minor skin irritation from removal of the tape. You will not be compensated for participation in this study.

5. FINANCIAL CONSIDERATION

There will be no financial compensation for participating in this study.

6. CONTACTS

Any questions regarding the study can be directed to Maggie Griebert (908-432-4762), Alan R. Needle, MS, ATC, CSCS (302-831-8222), or Thomas W. Kaminski, PhD, ATC, FNATA, FACSM (302-831-6402). Questions regarding the rights of the individuals who agree to participate in this research study may be directed to: Chair, Human Subjects Review Board, University of Delaware (302-831-2137).

7. SUBJECT'S ASSURANCES

I have read the above informed consent document. The nature, demands, risks and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and decide to

not be in this study at any time without penalty or loss of benefit to myself. A copy of this consent has been given to me.

8. CONSENT SIGNATURES

Subject's Name (printed) _____ Date: _____

Subject's Signature _____ Date: _____

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with being in this research study, have answered any questions that have been raised, and have witnessed the above signature. I have provided the subject with a copy of this informed consent document.

Signature of Investigator _____ Date: _____

Appendix B
LOWER-LEG INJURY QUESTIONNAIRE

A. Demographic Information

Date: _____

Age: _____ Height: _____ in/ _____ cm Weight: _____ lbs/ _____ kg

Dominant Leg: _____

B. Lower Limb Injury History

Have you suffered any injuries to your lower limbs in the past 4 months? _____

If so, please describe – injury, time, treatment

Do you currently or have you ever suffered from any neurological or general medical conditions? If so please explain:

C. Medial Tibial Stress Syndrome (Shin Splints) History

Have you ever been diagnosed with Medial Tibial Stress Syndrome (shin splints) by a physician? _____

If so, when? _____

Which leg(s)? Right Left Both

Have you ever been diagnosed with a stress fracture by a physician? _____

If so, where? _____

Have you ever suffered from any of the following injuries? (circle all that apply)

Plantar Fascitis	Right	Left	Both
Heel Spur	Right	Left	Both
Ankle Sprain	Right	Left	Both
Compartment Syndrome	Right	Left	Both
Achilles Tendon Rupture	Right	Left	Both
Lower-leg Fracture	Right	Left	Both
ACL Sprain/Tear	Right	Left	Both
PCL Sprain/Tear	Right	Left	Both
MCL Sprain/Tear	Right	Left	Both
LCL Sprain/Tear	Right	Left	Both
Meniscal Tear	Right	Left	Both
Patellar Tendonitis	Right	Left	Both
IT Band Tendonitis/Tightness	Right	Left	Both

Do you regularly participate in running activities? _____

If so, describe the activity (sport, sprints, long/short distance?)

Do you wear prescription or nonprescription orthotics or gel insoles?

Do you experience shin pain or lower-leg pain while running? _____

If so, where?

How often?

How long does it last?

If you run, what type of surface do you usually run on (grass, asphalt, track, turf)? _____

Do you ever experience muscles tightness in your lower-leg? _____

If so, where?

D. Allergy History

Have you ever had an allergic reaction to athletic tape and/or band-aids? _____

(An allergic reaction is defined as development of hives, rashes, blisters or excessive itchiness with the application of athletic tape and/or band-aids)

Have you ever had any irritation after wearing athletic tape and/or band-aids?

If so, what happened?
