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A Comparison of Two Tape Techniques on Navicular Drop and Center of Pressure Measurements

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A Comparison of Two Tape Techniques on Navicular Drop and Center of Pressure
Measurements

Krista M. Prusak

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of
Masters of Science

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ABSTRACT

A Comparison of Two Tape Techniques on Navicular Drop and Center of Pressure Measurements

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Masters of Science

Introduction: Foot over-pronation, attributable to Tibialis Posterior (TP) muscle weakness, is a possible cause of medial tibial stress syndrome (MTSS)³. Taping may provide a viable alternative for a dysfunctional TP and its associated navicular drop (ND). The most commonly used Augmented LowDye (ALD) technique has shown to prevent ND, but is time- and cost- intensive, leading us to explore an alternative technique. The purpose of this study was to assess the effectiveness of a new, anti-pronation (AP) taping technique, as compared to the ALD, to (a) reduce or prevent ND and (b) cause a lateral shift in the center of pressure (COP) measures. **Methods:** This is a 2 (tape techniques) by 3 (time: baseline, tape/pre-exercise, and tape/post-exercise) controlled laboratory study design. Twenty symptomatic (ND \geq 10 mm) college-age subjects were prepared with one of the 2 tape techniques and/or control and performed the ND test three times and walk across a pressure mat five times. Then the participants fatigued the tape by walking on a treadmill for 15 minutes at 3.0 mph at 0% grade and ND and pressure mat readings were recorded again. A within and within ANOVA allowed for the examination of between and within comparisons and a functional analysis (lateral shift as a function of time) on the mat-generated data were done $p < .05$. **Results:** Results revealed significant differences across times, and a times-by-tape technique interaction but differences between tape techniques were not significant. *M* and *SD* and indicate that while both taping techniques reduced ND, only the AP technique was significantly different ($HSD_{Tukey}(3,76)=1.44, p < .01$) for every comparison other than AP pre-exercise, the mean lateral shift for the treatment was not significantly different from the control across any part of the normalized stance phase, but was significantly lower than the control in the 30-90% interval in the AP pre-exercise. **Discussion:** The AP technique not only controlled ND but also resulted in an increase in lateral excursion of the COP line during that portion of the stance phase associated with the structures and functions of the TP. Both techniques can be appropriately used but that the AP can be used with more confidence in its effectiveness. The MatScan has allowed examination of forefoot pronation in the horizontal plane, not just the vertical plane, yielding a more holistic analysis of forefoot pronation. Being able to analyze data in a functional fashion (i.e., lateral shift as a function of time) could allow researchers greater insights to the complex relationships between biomechanical movement and appropriate interventions.

Keywords: medial tibial stress syndrome, taping, tibialis posterior, augmented LowDye, shin splints

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Introduction

Overuse lower leg injuries, though often of uncertain etiology, have many contributing factors such as anatomical, mechanical, training intensity, volume, and type.^{1,2} “Shin splints,” a catch-all phrase, has been used to describe a variety of conditions including compartment syndrome, periostitis, stress fractures, nerve entrapment syndrome, and various tendinopathies.^{3,4} More recently, the term shin splints has been used somewhat interchangeably with an equally ambiguous, but more medically descriptive phrase, medial-tibial stress syndrome (MTSS).⁵ This syndrome is characterized by, “Exercise-induced pain along the posteromedial border of the tibia not attributed to compartment syndrome or stress fracture, a common overuse injury”^{6,7} but again is of idiopathic origins.

There does, however, seem to be a common link of these varied pathologies with abnormalities in foot position, in particular to a drop in the position of the navicular bone resulting in a “fallen arch.”⁸ A fallen arch is often referred to as pes planus. In a neutrally aligned foot the heel strikes the ground at approximately 2 degrees of supination and moves through the neutral position and to a position of 3 ½ -4 degrees of pronation. The foot then re-supinates passing through neutral again into the toe-off phase. In a foot that is pes planus the ground reaction force’s point of pressure application, also known as the center of pressure (COP) is deviated more medially than those with a neutrally aligned foot. ⁹⁻¹² Williams¹³ found that low arched individuals have a more medial COP than those with high arches. Thus the authors of the present study make the assumption that should a subject with pes planus feet artificially lift the

arch the COP would trend the results found with the higher arched patients. According to these studies the COP may be useful in detecting changes in foot position throughout the stance phase of gait.

In a foot that is over-pronated the movement of the limb takes more energy to propel the weight of the body. This can cause foot and leg fatigue secondary to overuse of muscles. Pes planus feet have been associated with TP dysfunction.^{14, 15} One of the primary functions of the tibialis posterior (TP) is to contract eccentrically throughout the deceleration phase of foot pronation.¹⁶ If it is dysfunctional it cannot effectively control the force that must be transferred from the foot to the lower leg, leading to its inability to control the “falling” of the arch. This hyper-pronation during gait can result in lower-leg pain,³ which supports the theory that suggests foot over-pronation, attributable to TP muscle weakness, is a possible cause of MTSS.⁷

Several researchers^{17, 18} have looked at the effectiveness of taping or custom shoe inserts in an effort to control navicular drop (ND). Orthotic inserts have proven to be somewhat effective, but can become costly.⁵ Taping, may therefore, provide a viable alternative for a dysfunctional TP and its associated ND. The most commonly used Augmented LowDye (ALD) technique has been shown to prevent ND,¹⁹ but is time- and cost-intensive leading the present researchers to explore an alternative Anti-Pronation (AP) technique that is effective, yet simple and less costly. In addition to controlling ND, it should also cause a lateral shift in the COP during the stance phase of gait. This potential lateral shift can be measured via pressure mat (MatScan) readings.

The purpose of this study is to assess the effectiveness of the AP taping technique,

as compared to the ALD, to (a) reduce or prevent ND and (b) cause a lateral shift in the COP measures during walking. We hypothesize that relative to the ALD the AP tape technique will cause decreased ND and a more lateral trajectory of the COP during movement before and after exercise.

Methodology

Design

This is a 2 (tape techniques: ALD and AP) by 3 (time: barefoot baseline, tape/pre-exercise, and tape/post-exercise) controlled laboratory study design with all participants acting as their own controls.

Participants

Twenty (10 males and 10 females) college-age (age= $M 21.9 SD \pm 2.27$) volunteers with a ND ≥ 10 mm participated in this study. All participants were ambulatory (able to walk for 15 minutes) and free from lower-leg injury or pain within the previous month. Other exclusions included any lower limb injuries that happened in the last month. All participants filled out a letter of informed consent. All procedures received university IRB approval.

The significance level was also set at $p=.05$. Data were examined for normality using skewness and kurtosis statistics.²⁰

Instrumentation

Navicular drop. Navicular drop was determined using a ruler, index card, and pen according to procedures outlined in DeLacerda²¹ and which demonstrated adequate intra-tester validity and reliability.²²

Center of pressure. A pressure mat (Tekscan, Boston, MA, USA), embedded with 8,448 force sensels, was used to measure COP throughout the gait cycle. This system is valid and reliable.²³

Procedures

In advance of the proposed study, preliminary trials were conducted to (a) determine the most suitable type of tape to be used with the AP tape technique, and (b) refine and standardize all study procedures. Three different tape types were tested to determine which would be more suitable for this taping technique (white athletic tape, elasticon, and Leukotape.)

Leukotape, having consistently yielded the greatest reduction in ND, was selected for use in this study. The primary researcher, spent time sufficient to refine all study procedures such as taping technique consistency, testing procedures using the TekScan technologies, data collection procedures, and data reduction techniques.

Measurements.

The ND was tested according to the following procedure reported by DeLacerda:²⁴ The patients were seated with both feet on the floor, in a non-weight bearing position. The tester palpated the medial aspect of each foot and found the navicular prominence. Using a pen, the tester made a mark on the patient's skin at the point of the navicular prominence. Next, the tester stood the card on end on the floor next to the medial arch of the foot and marked the card at the level of the navicular prominence. Next, the patient stood up with weight evenly balanced between both legs. Once the arch was weight bearing, the tester made a second mark on the same side of

the card at the new level of the navicular prominence. This procedure was repeated with the other foot. The difference between the two marks for each foot was calculated and the foot with the greatest ND was used. A difference of greater than 10 mm was considered symptomatic.²⁵ This was done once to qualify for the study.

Center of pressure measurements were collected (100Hz) yielding a two-dimensional movie image of the stance phase from heel to toe and medial to lateral borders (i.e., a foot print; Figure 1). Participants practiced to determine the appropriate distance that required five walking steps with the fifth step striking the mat. With the pre-determined starting place, the participants were told to walk at a comfortable walking speed and focus on a picture on the adjacent wall to ensure gait was as normal as possible. Five stance images per condition per participants were recorded.

Session protocol. The taping techniques were randomly assigned. Data were collected over two similar one-hour sessions by the primary researcher as follows.

1. Upon arrival at the testing facility, participants filled out a survey designed to collect demographic and other pertinent data (e.g. gender, height, weight, history, activity patterns, etc.; Appendix A)
2. Demographic data specific to the participant needed for the TekScan software was entered into the computer. (i.e height weight and gender)
3. Unshod participants were measured with respect to (a) ND (average of three measurements) and (b) COP (average of five stance images).

4. Next, participants were taped by the same person, according to procedures listed below, and both measurements (ND and COP) were repeated (see Appendix A: Figures 14-27).
5. To determine the effectiveness of taping technique following a bout of exercise, participants walked, unshod on a treadmill for fifteen minutes at 3.0 mph at 0% grade on a Quinton Q65 Series 90 Treadmill (Quinton Instrument Co., Bothell, WA, U.S.A.).
6. After the exercise bout, both measures (ND and COP) were repeated.
7. Within three weeks, session two employed the same procedures described above.

The following taping procedures were used. The ALD taping technique is a combination of the LowDye, three reverse sixes, and two calcaneal slings (Appendix A: Figures 23-25). The LowDye technique is accomplished by a spur being attached on the medial aspect of the foot and wrapped around the foot to the adjacent side followed by mini stirrups going from the lateral side of the foot on the spur to the medial side on the spur (Appendix A: Figures 14-16). The reverse sixes is accomplished by laying down anchors followed by three strips of tape that lay across the top of the foot medial to lateral, cross under the foot lateral to medial and back up the medial side crossing the anterior portion of the ankle joint (Appendix A: Figures 17-19). The calcaneal sling technique is done by laying down one anchor strip followed by two strips that start on the anterior tibia and follow a pattern distally and just anterior to the medial malleolus

continuing under the foot, and around the calcaneus and back up to the anchor strip (Appendix A: Figures 20-22). No pre-wrap will be applied with this tape procedure.

The AP technique consists of a single piece of pre-tape that starts on the lateral foot, just anterior to the lateral malleolus. It crosses under the foot and crosses the medial foot at the navicular tubercle and anterior calcaneus. It then covers the medial malleolus and spirals across the leg to the shaft of the fibula. Two pieces of tape are administered in a similar fashion with the strips overlapping by a half an inch. These strips are pulled taught while crossing under the foot to put the foot in an inverted position (Appendix A: Figures 26-27). An anchor strip was applied to hold the strip down.

The tape type that was used in this experiment was Leukotape P Sports Tape, which is rayon-backed tape with an aggressive zinc oxide adhesive (BSN medical, Inc. Charlotte, North Carolina). The Leukotape will be used in conjunction with Cover-Roll Stretch, to aid in skin protection in the anti-pronation tape technique. This 4" x 10 Yards Non-Woven Adhesive Bandage is hypoallergenic, self-adhesive, air-permeable, and cross elastic (BSN medical, Inc. Charlotte, North Carolina). Pre-tape spray was used with both tape techniques. (Mueller Sports Medicine Inc, Prairie du Sac, WI)

Data Collection and Analysis

Independent and dependent variables. Demographic data (height, weight, health, physical activity level, uses of orthotics, lower limb surgery/therapy/injury, gender, etc.) were collected via an initial questionnaire (see Appendix A). Descriptive data were computed to examine means, standard deviations, frequencies, etc.

The independent variables are the tape techniques (control, ALD and AP) and time (baseline, tape pre-exercise, tape post-exercise). Raw, dependent variable data points for each of 20 participants were generated by three navicular height measurements per condition ($n=360$) and five stance phase MatScan images per condition ($n=600$).

Navicular drop. All ND data were input into SPSS. A two (tape techniques) by three (times) within and within, repeated measures ANOVA was used as the omnibus test to assess any possible differences.

Center of pressure line. Stance images were measured using the pressure mat. Because it was impossible to assure that each stance profile (i.e., foot size, mat location, and length of stance phase) were the same, data standardizing techniques (described in context below), were applied to lateral shift distance data points for further analysis.

Determining the COP line, calculating lateral shift of COP, and data reduction procedures. The COP line is a curvilinear line that connects the beginning of the COP of the heel strike and ending at the COP of the toe-off phase (Figure 1). Calculating the lateral shift of the COP line first required establishing a standard reference line. A straight line extending from the COP in the heel strike to the most medial point on the boarder of the big toe during the COP in the toe-off phase (Figure 1) was established for each of five trials for 20 participants across six conditions ($n=600$; Figure 1). The distance from the COP line to the reference line was determined with the point-line equation by Weisstein (Figure 2) for each COP cell throughout the stance phase. In other words, this distance between the two lines was calculated for each point along the COP line. Then the resulting distances, in each of the 600 trials, were used to calculate the difference

between conditions. A set of differences, was calculated and then averaged for each of five trials for 20 participants for each of the six conditions ($n=600$ trials). Individual means in each condition were averaged to create conditional means, which were then used for all subsequent analyses.

Multivariate analysis of lateral shift as a function of time. A multivariate functional (lateral shift as a function of time) analysis was used to assess the between group (tape techniques) and within (times) differences. This analysis observed the stance phase as a polynomial function rather than a discrete data point, allowing for an observation of where differences exist during the entire duration of the stance phase. Traditional analysis of variance statistical methods would require an examination of lateral shift at a specified point during the stance phase. Using multivariate analysis of variance, also known as a functional analysis, examination of lateral shift can be accomplished at many different time points simultaneously. However, if the functional nature of the data is preserved (i.e., examining lateral shift as a function of time), all data will be able to be used and more interpretable results found. Hence, the lateral shift was used as a function of time as the response variable. Using functional analysis of variance, the mean lateral shift was examined for each condition. The functional data analysis methods were used to determine which parts of the stance interval are significantly different in lateral shift between conditions.

Transforming and normalizing lateral shift data. First, it was necessary to transform the lateral shift data into actual functions using cubic smoothing splines.²⁶ Next, these functions were normalized to have the same end points (Figure 4-7) using linear

warping functions. This normalizing procedure accounts for amplitude variation in the functions due to individual differences in foot size or stance phase duration.²⁶ With the functions normalized, altitude variation in the functions was analyzed to determine if there were any statistically significant differences from the zero function in lateral shift throughout the stance phase (i.e., as a function of time) across all six conditions.

Results

Descriptive and navicular drop. Descriptive data for all participants are listed in Table 1 (Appendix A). Data were determined to be normal (both skewness and kurtosis within ± 2.0)²⁰ and sphericity was assumed (Mauchly's $W=.927$, $p=.246$). Results from the within and within, repeated measures ANOVA omnibus analysis revealed significant differences across time (barefoot baseline, tape/pre-exercise, tape/post exercise) ($F_{(2,76)} = 17.41$, $p \leq .000$), and a significant tape technique-by-times interaction from barefoot to the tape/pre-ex condition ($F_{(2,76)} = 3.87$, $p = .025$). Post hoc comparisons were then made via Tukey's Honestly Significant Difference (HSD_{Tukey}) indicating that while both tape techniques reduced ND, only the AP technique was significantly different from the barefoot baseline at $p < .05$ ($HSD_{Tukey}(3,76) = 1.44$, $p < .01$) in both the tape/pre-exercise and tape/post-exercise conditions. There was a significant difference ($HSD_{Tukey}(3,76) = 1.14$, $p < .05$) between the AP and ALD at the tape/pre-exercise and tape/post-exercise condition. All other comparisons were found to be non-significant at the $p \leq .05$ level. Means and standard deviations for all conditions are found in (Figure 3).

Functional analysis. Referring to Figures 8-13 the functional analysis to determine lateral shift of the COP is interpreted as follows: The black line in the middle of the

shaded region is the *mean difference* in lateral shift (except on the control, where it is the mean lateral shift). The shaded region is the 95% confidence area. Thus, if the confidence area contains the red dotted line at 0, the mean difference function is not significantly different from 0 (or the 0 function), meaning that the lateral shift for the given treatment is not significantly different from the control. Results indicate that for every comparison other than AP Pre-exercise, the mean lateral shift for the treatment was not significantly different from the control across any part of the normalized stance phase (95% confidence) (Figures 8-11 and 13). For AP Pre-exercise, results indicate that the mean lateral shift was significantly different from the control, between 30 and 90% of stance (Figure 12).

Discussion

The purpose of the study was to examine the effectiveness of a new taping technique designed to control mechanical variables that may be pathological contributors to MTSS. Specifically ND and over-pronation resulting in possible stresses or injury to the TP and its associated structures and functions.

We hypothesized that the AP technique would be as or more effective than the traditional ALD technique at controlling ND, and cause a lateral shift in the COP, but would also have several additional advantages (i.e., cost, time, and convenience). Results of this study indicated that these hypotheses were generally upheld.

Controlling ND and lateral shift was of interest in this study due to its relationship to the the structures and functions of the TP and its hypothesized role in MTSS. It was expected that there would be a lateral shift in the COP line but the level of

sensitivity of the functional analysis revealed an even more targeted result than anticipated. It showed where in time the changes in COP were seen – specifically during moments from 30-90% of the stance phase. In other words, the AP technique not only controlled ND in the tape/pre-exercise and tape/post-exercise conditions, but also resulted in an increase in lateral excursion of the COP line, in the pre-exercise condition, during that portion of the stance phase associated with the structures and functions of the TP.^{27, 28}

Franettovich found that the augmented LowDye reduces activity of the TP muscle during walking while increasing arch height. She feels that this provides evidence of the TP's role in reducing the load on the ankle and the foot.¹⁷ Franettovich interprets several studies that look at the effect of anti-pronation tape techniques on the biomechanics of the foot and ankle.¹⁸ She states that there has been reported change in ND and plantar pressures, both static and dynamic among other reported changes as reported by Vicenzino.^{18, 19} This article reports of evidence in support of anti-pronation tape exerting a biomechanical effect in reducing foot pronation.^{18, 29} There is also research showing that there is a neurophysiological effect on the TP during dynamic tasks.^{17, 18} In comparison, the present study provides evidence that the AP technique is as or more successful than the ALD described in these studies.

The results of the COP comparisons were made possible by the MatScan data used in combination with a functional analysis and could have future implications for use in a variety of biomechanical studies. This technology has allowed us to examine stance as a product of COP excursion in the horizontal plane, not just the vertical plane

like the ND test. This yields a more complete analysis of foot position throughout the stance phase.³⁰ Additionally, being able to analyze data throughout time, could allow researchers greater insights to the complex relationships between biomechanical movement and appropriate interventions. In this case, transposing a set of discrete data points into a function equation allowed for the examination of differences across the entire duration of the stance phase simultaneously as opposed to one moment in time or representing the entire stance phase as a single variable. This functional analysis provided the means to not only detect significant differences between tape techniques but also to narrow those differences to a specified interval of the stance phase. This level of sensitivity may hold promise for paring out other biomechanical alterations due to injury or dysfunction.

Murley et al.²⁷ described biphasic TP activity, during the stance phase of walking. The first phase is at initial contact, and the second phase is during midstance. This two-burst sequence could possibly reduce the load on associated contractile and non-contractile tissues and reduce injury risk. Perry²⁸ reported similar TP characteristics during the stance phase of walking. When considered with the present results, these EMG findings may indicate that the COP changes associated with the AP technique are associated with potential change in TP activity i.e., the AP technique may assist the TP in eccentrically contracting during 30-90% of stance and controlling pronation and arch collapse.

An initial concern about the AP technique is that it requires putting the foot in extreme inversion, and whether that would introduce additional risk for lateral ankle

instability by shifting the COP line too far laterally. Results of this study indicated that no additional lateral COP movement was noted except in a very targeted portion of the stance phase, specific to the functions and structures of the TP (Figure 12). More data are needed to determine how this deviation compares to COP excursion in normal subjects and whether the lateral deviation could possibly result in injury.

The results of this study may hold some important implications for clinicians. The AP technique was shown effectively control ND (tape/pre-exercise and tape/post exercise) and TP functions related to COP in the intended targeted times with the tape/pre-exercise condition. These results also lend support to recent trends towards more minimal, but functional taping techniques such as those described by Alexander³¹ and Celiker.³² Part of this trend is made possible by relatively newer types of tape such as kinesiological tape and the leukotape used in this study. Thus exploring new techniques would seem to be a prudent endeavor. For these reasons, we recommend this tape technique as a possible intervention strategy for MTSS.

To conduct this examination we used a cross-over, repeated measures, factorial design with two sessions within a three-week period assuring that the effects (such as fatigue) of one session did not confound the results of the second session.

Since this study only includes a physically active adult population, the generalizability of the results is limited to a population of similar age and fitness level. Other limitations include tape type (Leukotape). While some initial testing was done on various other tapes, no empirical data were collected for a definitive comparison. The authors made the assumption that the tape applications change the force that is

transferred up the foot to the lower leg. More research is needed to see the long-term effects of the tape technique on the lower-leg. Another limitation was the self-selected walking speed. One of the tape techniques was more uncomfortable for the patients to wear and their pace could have changed between tape techniques.

The exercise period was limited to only 15 minutes of walking. All tape tends to lose tautness over-time. We saw that the AP tape technique was superior taped/pre-exercise with respect to the ND and COP then after our brief exercise bout the AP technique was as equally effective at the ALD at the taped/post-exercise with respect to the COP, but did continue to see a significant difference taped/post-exercise with respect to the ND. More research is needed to test a longer exercise condition with a shod foot.

Conclusion. Research has shown that MTSS caused by a dysfunctional TP and associated ND can be effectively controlled with the time- and cost-intensive ALD tape technique. In contrast the alternative AP technique created controlled the ND in both the tape/pre-exercise and tape/post-exercise conditions and also caused a more lateral COP trajectory in the taped/pre-exercise condition. This tape technique is simple and minimalistic following the trends in functional taping. Therefore, we recommend this tape technique as a possible intervention strategy for MTSS.

Subject	Order	Gender	Height (m)	Mass (kg)	Physical Activity			
1	2	M	1.73	88.45	4			
2	1	M	1.83	87.09	2.5			
3	2	F	1.63	69.09	1			
4	2	F	1.75	126.09	3.5			
5	2	F	1.68	82.95	4.5			
6	2	M	1.70	80.82	3			
7	1	M	1.88	71.23	6			
8	1	F	1.73	59.82	3			
9	2	F	1.68	62.63	5			
10	2	M	1.88	99.23	5			
11	2	F	1.65	64.32	3			
12	1	F	1.73	75.41	5			
13	2	F	1.63	76.77	4			
14	2	F	1.52	72.72	4			
15	2	M	1.83	81.59	5			
16	1	M	1.85	73.73	4			
17	1	F	1.78	75.77	2			
18	1	M	1.78	78.18	5			
19	2	M	1.83	107.18	3.5			
20	1	M	1.80	84.09	6			
			<i>M=1.74</i>	<i>SD=.096</i>	<i>M=80.69</i>	<i>SD=15.64</i>	<i>M=3.95</i>	<i>SD=1.3</i>
Note: Order indicates which taping technique was used first (ALD=1 AP= 2)								

Table 1: Descriptive data for all participants

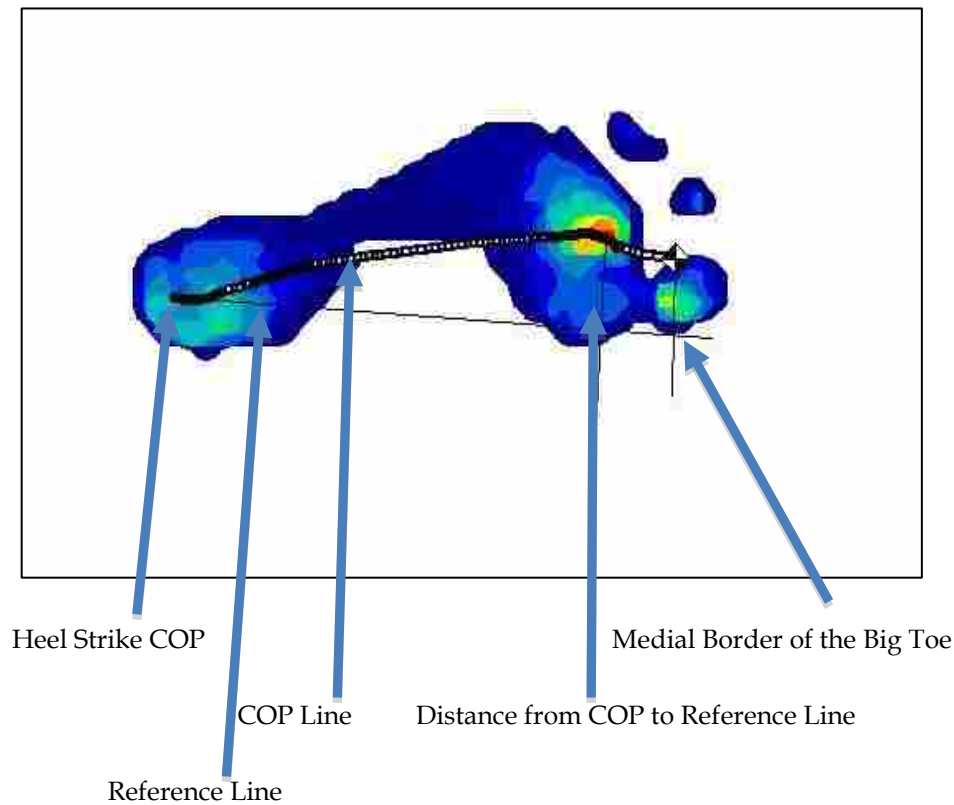
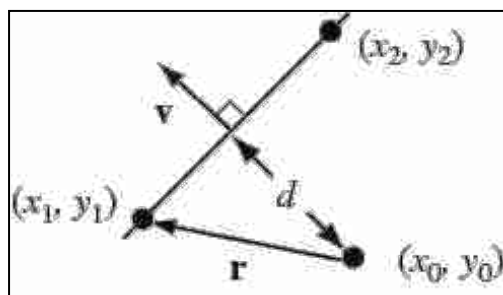


Figure 1- MatScan visual of peak stance with a superimposed COP line and reference line. The dark line through the foot is the COP line. The Thin Line connecting the heel to the big toe is the reference line. The lines vertically connecting the two line are demonstrative of the distance from the COP to the Reference.



$$d = |\hat{\mathbf{v}} \cdot \mathbf{r}| = \frac{|(x_2 - x_1)(y_1 - y_0) - (x_1 - x_0)(y_2 - y_1)|}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}$$

Figure 2- Visual Demonstration of the Reference Line to Point on the COP Line and Equation with the Shortest Distance From a Point to a Line Equation

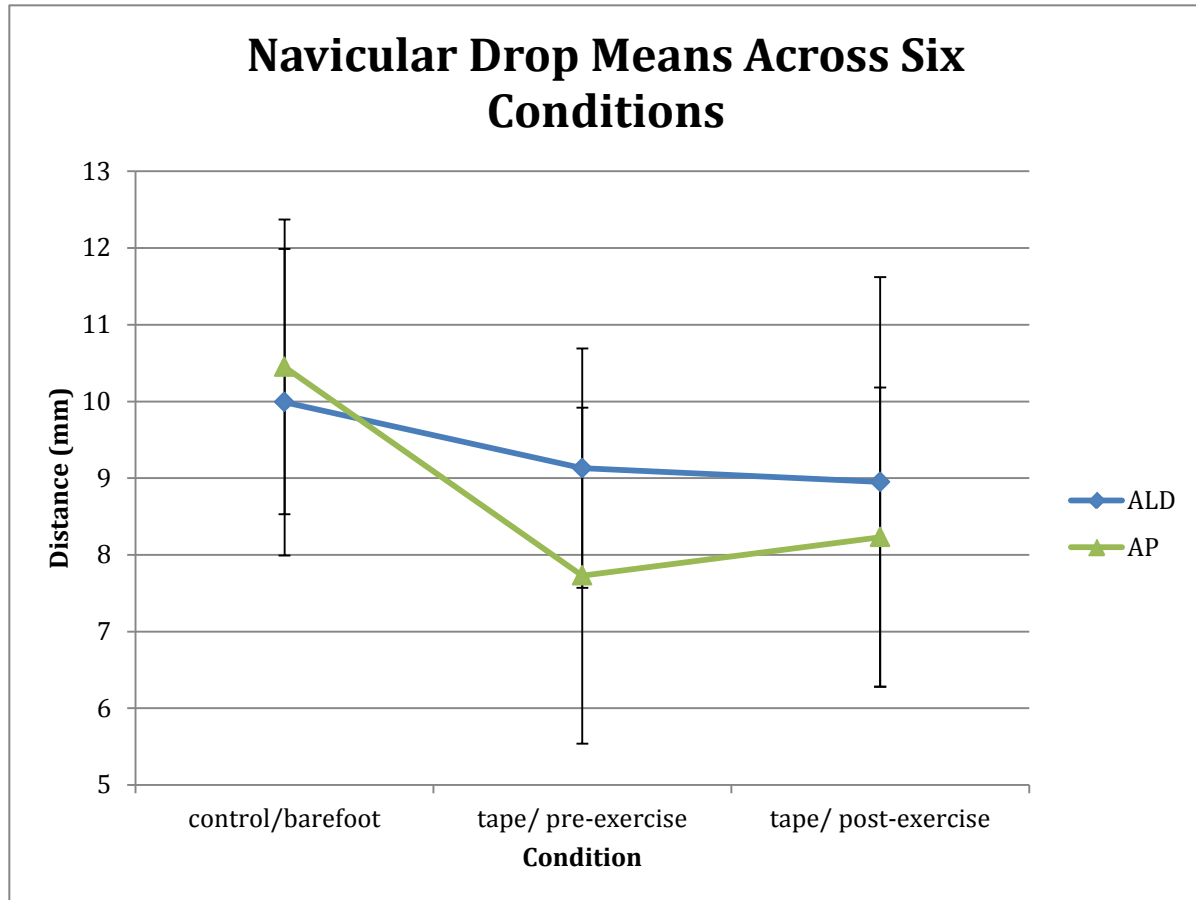


Figure 3- Navicular drop means across six conditions. While both taping techniques reduced ND only the AP technique was significantly different than the barefoot control ($p < .01$). There is times-by-tape technique interaction ($p = .025$) indicating that the AP is significantly more effective than the ALD across conditions.

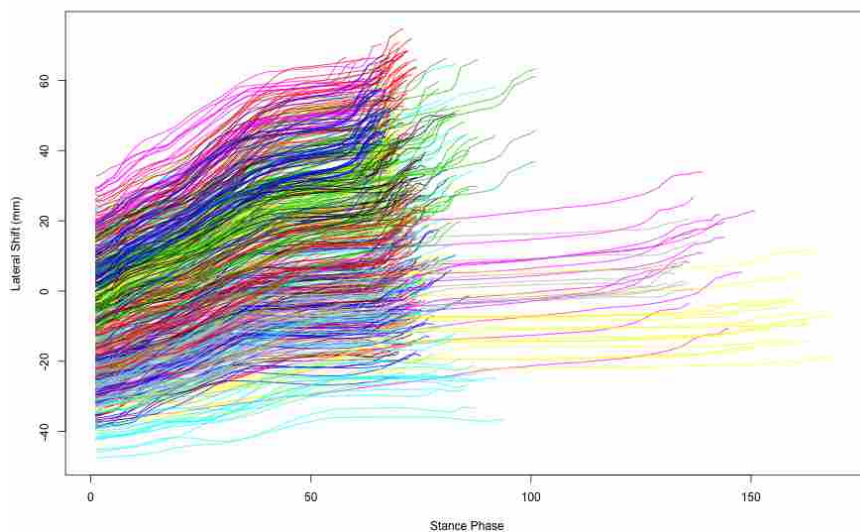


Figure 4- Pre-normalized spaghetti plot: by individual. Each of five trials are represented by individual lines. Different colors represent each participant.

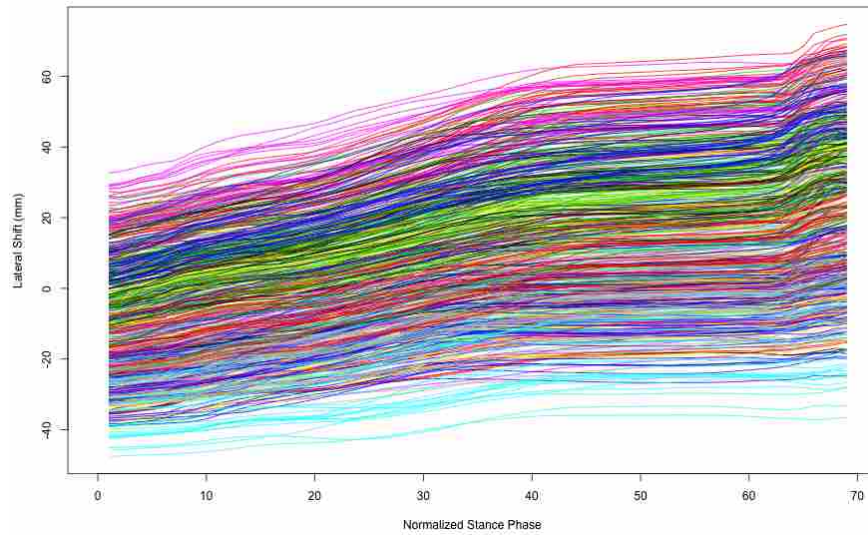


Figure 5- Normalized spaghetti plot: by individual removes individual differences due to foot size and stance phase.

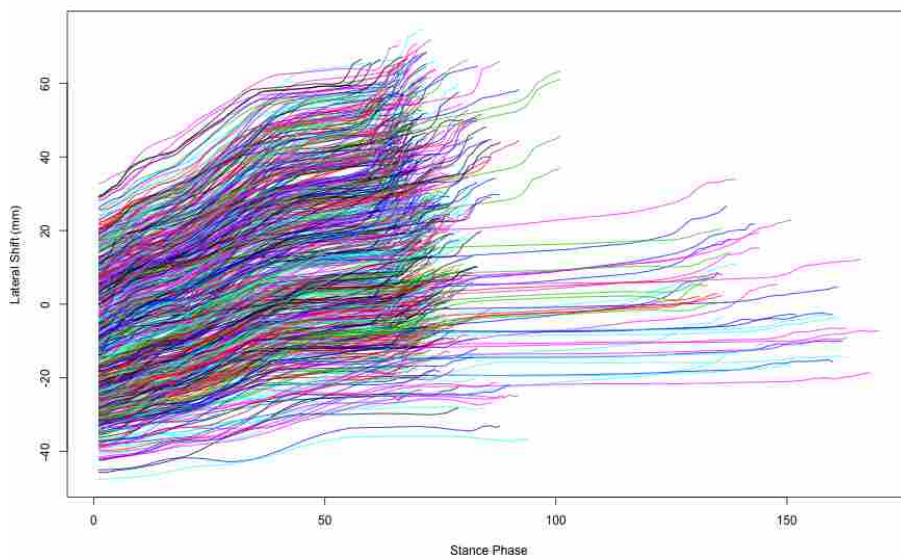


Figure 6- Pre-normalized spaghetti plot: by condition. Each of the three conditions are represented by individual lines. Different colors represent each treatment condition.

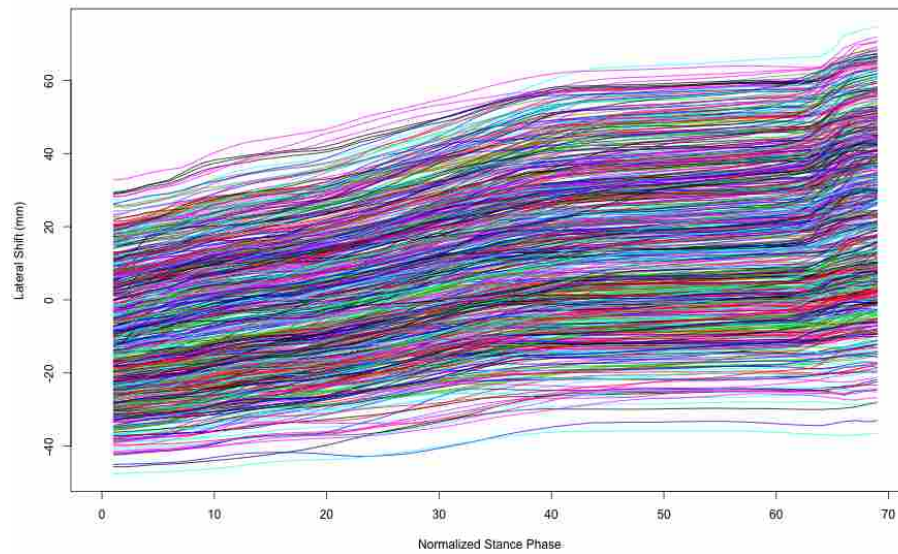


Figure 7- Normalized spaghetti plot: by condition. Each of three conditions are represented by individual lines. Different colors represent each treatment condition.

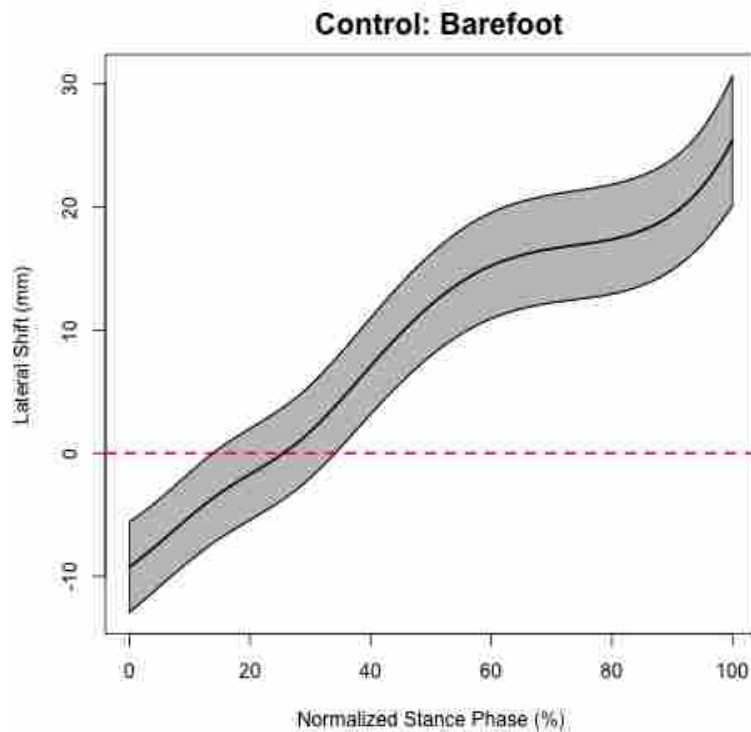


Figure 8: Functional Analysis Control Barefoot 1

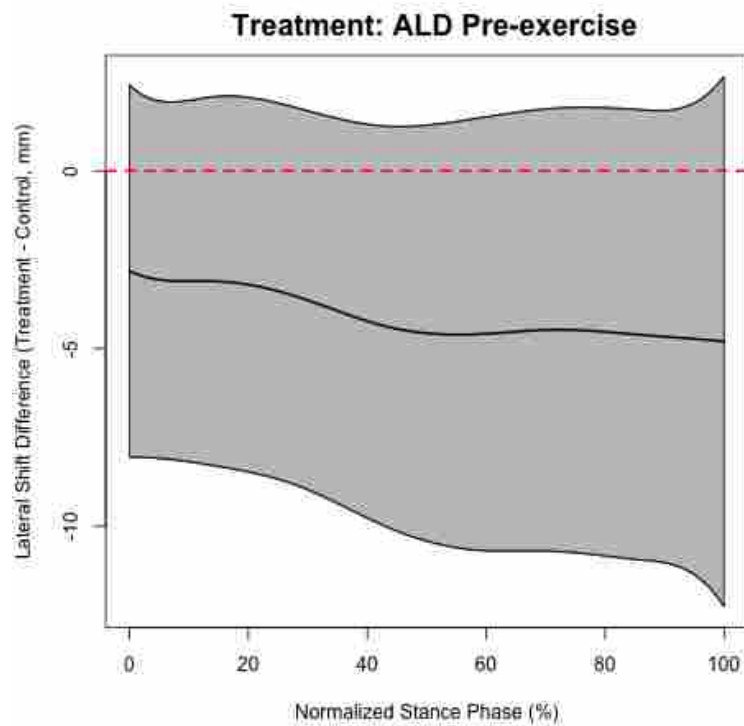


Figure 9: Functional analysis ALD pre-exercise. Comparing the ALD treatment pre-exercise to the control shows that the mean difference (treatment minus control) function is negative, but that the 95% confidence intervals for this function span zero. Thus, we cannot conclude that there is a significant difference between ALD pre-exercise and the control at the 5% level.

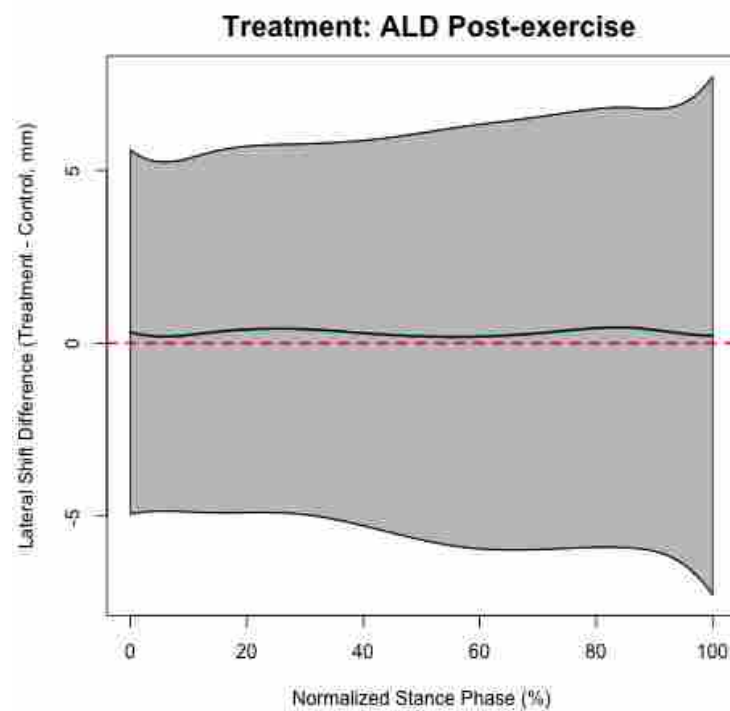


Figure 10: functional analysis ALD post-exercise. Comparing the ALD treatment post-exercise to the control shows that the mean difference (treatment minus control) function is negative, but that the 95% confidence intervals for this function span zero. Thus, we cannot conclude that there is a significant difference between ALD pre-exercise and the control at the 5% level.

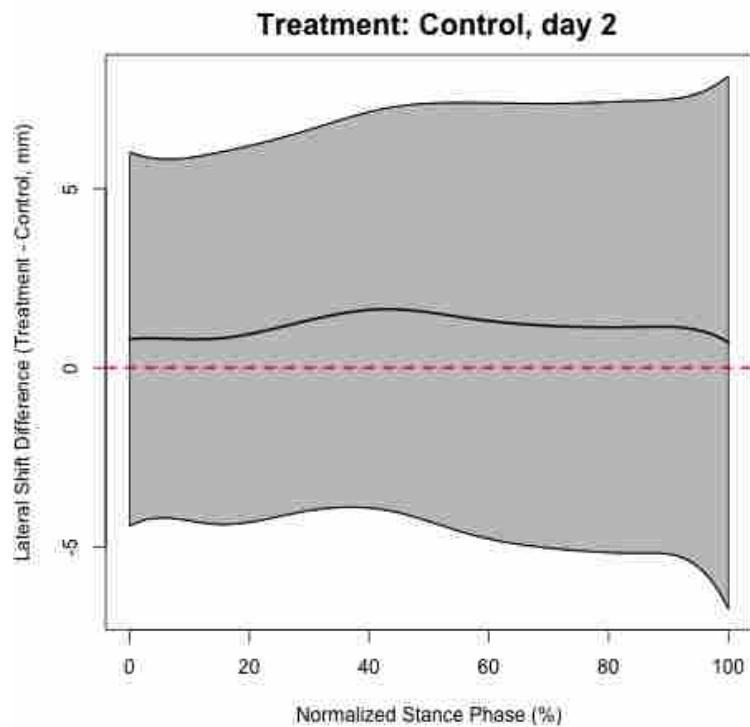


Figure 11: Functional Analysis Control Barefoot 2

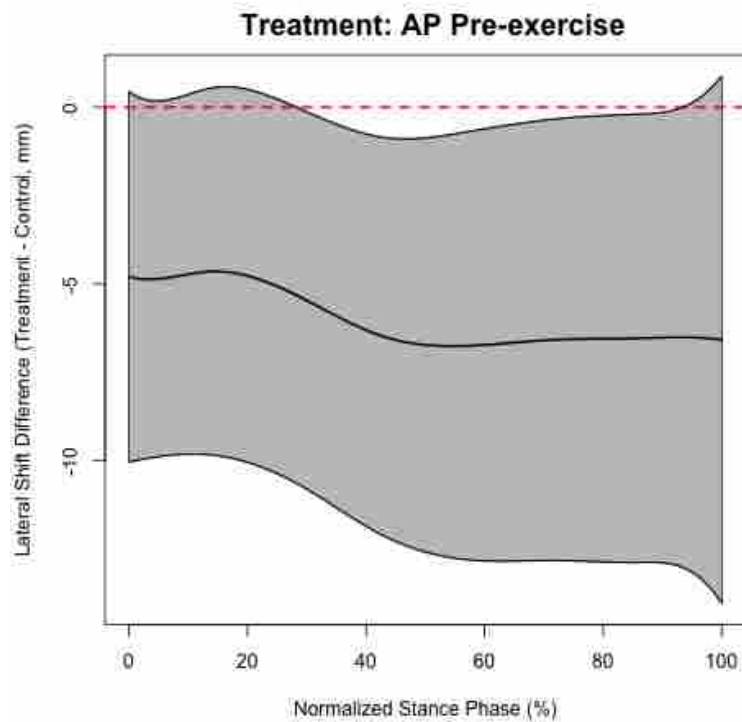


Figure 12: Functional analysis AP pre-exercise. Comparing the AP treatment pre-exercise to the control shows that below the 32nd percentile of the stance phase, the difference function is again not significantly different from zero at the 5% level. However, from the 32nd to the 92nd percentile of stance phase, the mean difference function (treatment minus control) is significantly negative at the 5% level. The plot indicates that the mean difference is between -7 and -5 between the 32nd and 92nd percentiles of stance phase. This means that, for example at the 45th percentile of the stance phase, the treatment reduces mean lateral shift by 7mm with 95% confidence interval (1mm,12mm).

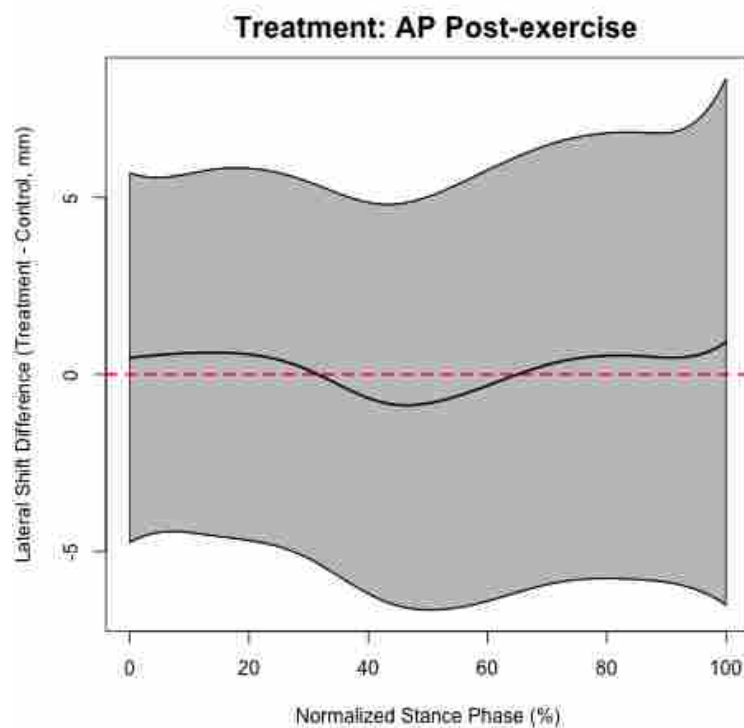


Figure 13: Functional analysis AP post-exercise. Comparing the AP treatment post-exercise to the control shows that the mean difference (treatment minus control) function is negative, but that the 95% confidence intervals for this function span zero. Thus, we cannot conclude that there is a significant difference between ALD pre-exercise and the control at the 5% level.

Prospectus

Introduction

Over use lower leg injuries, though often of uncertain etiology, such factors such as anatomical, mechanical, training intensity, volume, and type are suspected to contribute.^{1,2} “Shin splints,” a catch-all phrase has been used to describe a variety of conditions including compartment syndrome, periostitis, stress fractures, nerve entrapment syndrome, and various tendinopathies.^{3,4} More recently, the term shin splints have been used somewhat interchangeably with an equally ambiguous, but more medically sounding phrase, medial-tibial stress syndrome (MTSS).⁵ This syndrome is characterized by, “Exercise-induced pain along the posteromedial border

of the tibia not attributed to compartment syndrome or stress fracture, a common overuse injury.”^{6,7} but again of idiopathic origins.

There does, however seem to be a common link of these varied pathologies with abnormalities in foot position and in particular to a drop in the position of the navicular bone resulting in a “fallen arch.”⁸ One theory suggests that, foot over-pronation, attributable to tibialis posterior (TP) muscle weakness, is a possible cause of MTSS.⁷

The TP, with one of its primary functions to contract eccentrically throughout the deceleration phase of foot pronation,¹⁶ if dysfunctional cannot effectively control force that must be transferred from the foot to the lower leg, leading to its inability to control the “falling” of the arch, hyper-pronation during gait, and resulting in lower-leg pain.³

Several researchers^{17, 18} have looked at the effectiveness of taping or custom shoe inserts in an effort to control ND. Orthotic inserts have proven to be somewhat effective, but can become costly.⁵ Taping, may therefore, provide a viable alternative for a dysfunctional TP and its associated ND. The most commonly used Augmented LowDye (ADL) technique has shown to prevent ND, but is time- and cost-intensive leading the present researchers to explore an alternative anti-pronation technique that is effective, yet simple and less costly. In addition to controlling ND, its effectiveness should be accompanied by a lateral shift in the center of pressure (COP) measures available via pressure mat (MatScan) readings.

Purpose Statement

Therefore, the purpose of this study is to assess the effectiveness of a new, anti-pronation taping technique, as compared to the ALD, to (a) reduce or prevent navicular

drop and (b) cause a lateral shift in the COP measures.

Hypothesis

We hypothesize that that the anti-pronation tape technique will be as or more successful as the ALD, with success being defined as (a) a decrease in navicular drop and (b) an increased lateral center of pressure position from ground contact to toe off.

The null hypothesis is that the anti-pronation technique will not have statistical effect on the aforementioned dependent variables.

Delimitations

1. This study will be limited to one tape type. (Leukotape, BSN medical, Inc. Charlotte, North Carolina)
2. Taping techniques will include the ALD technique and AP technique, excluding all other forms of foot pronation taping techniques.
3. Participants will be selected from a pool of physically active persons with a ND of 10 mm or greater.
4. Participants will be adults age 18 and above.

Limitations

1. Results will be limited to interpretation only with respect to treadmill walking and a static stance.
2. There is no test for direct relation to MTSS healing.

Assumptions

The researchers are making the assumption that because of its role in the deceleration phase in foot pronation, that the TP is associated with MTSS.

Operational Definitions

1. Shin Splints- pain and discomfort in the leg from repetitive running on hard surfaces or forcible extensive use of foot flexors; the diagnosis should be limited to musculotendinous inflammation, excluding a fatigue fracture or ischemic disorder.^{3,4}
2. Medial Tibial Stress Syndrome- exercise-induced pain along the posteromedial border of the tibia not attributed to compartment syndrome or stress fracture, a common overuse injury of the lower limb.⁶
3. Navicular Drop Test- Test used to determine the amount of drop experienced in the medial longitudinal arch during weight bearing. Positive findings suggest weakness in foot pronators.³³
4. Physically Active Population- a classification of active represents an average of 3 or more hours per week of exercise for 9 or more months of the year.³⁴

Review of Literature

Background

Overuse injuries are common in any physically active population occurring when there is sub-threshold, repetitive trauma to a structure that results in fatigue and abnormality in the tissues.^{1,2} Though often of uncertain etiology, such factors as anatomical, mechanical, training intensity, training volume, and training type are suspected to lead to overuse injuries.

Overuse injuries in the lower extremity, often referred to as Exercise Related lower Leg Pain (ERLP) is commonly defined as:

“Exercise-related leg pain is a term used to describe lower extremity overuse conditions in which pain is located distal to the knee and proximal to the talocrural joint and is associated with exercise.”³³

However, since many injuries can be lumped into the ERLP definition (e.g., shin splints, and anterior compartment syndrome, tendinopathies, and fractures, and medial tibial stress syndrome) this broad definition can lead to confusion, as there is not a specific injury related to the cause. Thus, prevention and treatment measures can likewise be uncertain.

“Shin Splints” is a long used umbrella term that describes both ERLP and lower leg injuries commonly occurring in athletic and military communities.^{1, 4} In 1966 the American Medical Association (AMA) defined shin splints as, “pain and discomfort in the leg from repetitive running on hard surfaces or forcible extensive use of foot flexors; the diagnosis should be limited to musculotendinous inflammation, excluding a fatigue fracture or ischemic disorder.”³⁴ “Shin splints” has, at one time or another, been used to describe conditions including compartment syndrome, periostitis, stress fractures, nerve entrapment syndrome, and various tendinopathies.^{3,4} Using this catchall phrase to define many injuries is problematic as it fails to bring clarity for either diagnosis or treatment.

More recently, the term ‘shin splints’ have been used somewhat interchangeably with an equally ambiguous, but more medically sounding phrase, Medial-Tibial Stress Syndrome (MTSS).⁵ This syndrome is characterized by, “Exercise-induced pain along the posteromedial border of the tibia not attributed to compartment syndrome or stress

fracture, a common overuse injury.”^{6,7} but again of idiopathic origins. For the purposes of this paper, we will use the term MTSS.

Research over the past two decades into the causes of MTSS has focused on two main sources – those arising from either extrinsic- (external or environmental), or intrinsic- (internal or personal) factors. Scheuch states that clinicians should concentrate on the cause of the injury so to eliminate the factors involved and then the true correction of the injury can occur.¹⁶

Extrinsic Factors

Extrinsic factors are those arising from external or environmental factors rather than from internal or personal factors or sources. Scheuch¹⁶ describes some of the most common extrinsic factors to be a change in activity intensity, equipment or terrain. Running shoes with little or no arch support can cause a collapse of the medial arch and cause hyperpronation. Also running in one direction on a terrain with a bank on one side can also cause pain or produce symptoms.¹⁶ Thacker states that any factor related to the sport, such as the status of the floor or field, may be an extrinsic factor.³⁵ Sommers also states that an increase in activity without proper conditioning and, or a recent change in equipment often sets the stage for overuse injuries.³⁶

Intrinsic Factors

Intrinsic factors are those within a person, rather than from an external source. There have been proposed several intrinsic factors that contribute to MTSS. Reinking states that factors such as gender, foot pronation, and muscle flexibility contribute to overuse injuries.³³ Some authors^{36,37} state that unaccustomed eccentric action of the

plantar flexors can be a major precipitation factor. Thacker states that factors such as anatomical variations (e.g. fitness level, experience, and previous injury) also play a large role in MTSS³⁵.

Thacker³⁵ stated that several studies point to the role of increased foot pronation as a risk factor for shin splints such as found by Bennett et al.³⁸ He found that there is an association between foot pronation and ERLP. Willems² found that the subjects that developed ERLP demonstrated significantly greater foot pronation and medial foot pressure during the stance (from heel strike to toe off) phase of running.

Anatomy

A brief discussion of the key anatomical structures and their functions involved in MTSS, particularly the soleus complex, and the TP as related to surrounding bony structures, is warranted.

The soleus is deep to the gastrocnemius, originating on the upper portion of the tibia and fibula, is common to the Achilles tendon and inserts on the calcaneal tuberosity. It is considered important for its role as an eccentric stabilizer as the foot moves from supination to pronation. The TP muscle, situated deep, beneath the gastrocnemius on the posterior aspect of the tibia has its origins on the upper half of the posterior surface of the interosseous membrane and adjacent parts of the tibia and fibula. Its insertion is on the inferior surface of the navicular and adjacent tarsal bones. The tendon turns 90° at the medial malleolus (in a cable and pulley fashion) and is a prime-mover for inversion and assists with plantar flexion.¹⁶ Most salient to this paper is its eccentric role in the deceleration phase of mid-foot pronation.

Foot Pronation

Foot pronation serves as a mechanism, which absorbs ambulatory generated forces as the foot comes in contact with an unyielding surface. Both the medial portion of the soleus, and in particular, the TP contract eccentrically to slow down foot pronation thus delivering its shock absorption benefit.³⁹ If there is excessive eccentric stress placed on the TP, tendonitis ensues. Because of its location, the radiating pain from the TP is thought to be a likely cause for the characteristic pain associated with MTSS.³⁹

Studies examining various aspects of this force absorption mechanism have revealed relevant findings. As early as 1988, Messier and Pittala found that a correlation between excessive foot pronation and excessive eccentric muscle contraction during the deceleration phase of foot pronation was likely related to MTSS.³⁹ Sommers and Vallentyne³⁶ found that dancers who had excessive varus foot positioning (toe out) were more likely to experience MTSS. Bennett et al. showed that those with MTSS exhibited a significantly larger ND than those who were asymptomatic.³⁸

More recently, Yates,⁴ described a condition with naval recruits wherein those with greater foot pronation experienced higher incidence of MTSS. Reinking cited that the inflexibility of the gastrocnemius-soleus complex combined with excess foot pronation is a risk factor for MTSS.³³ Craig states that, the relative contributors to excess foot pronation are soleus tightness and soleus fatigue. She goes on to state that excess pronation requires the soleus to eccentrically contract longer, which will cause more stress at the origin of the muscle leading to MTSS.³⁹ Excessive eccentric forces during

the deceleration phase of foot pronation are thought to lead to inflammation and eventually to MTSS.

Murley et al. report in their EMG study that there is biphasic activity in the TP muscle in the stance phase of walking. The first phase is during contact, or right before heel strike and the second is during midstance or propulsion phase. They suggest that this may be a sign of a mechanical role to resisted pronation of the hind foot during walking and be in opposition to muscle activity of the peroneal muscles. They also found that there was a synergistic action, supination and pronation, with the peroneus longus to stabilize the hind foot during the gait cycle. They concluded that those with normal foot posture tend to have an EMG reading with the TP having a two burst sequence, and this could possibly reduce the load on those contractile and non-contractile tissues to reduce the risk injury.²⁷

Murley, Menz, and Landorf similarly tested the EMG activity of the TP and found that the subjects with low or flat arched feet had an increased peak EMG and RMS amplitude suggesting that those who have low arches function at a higher percentage of their maximum amplitude than those with normal arches, meaning the TP is working harder. This is because the lower arched foot has a greater load on the foot ligamentous structures during walking and the TP has to work harder to contract and protect those structures.⁴⁰

A commonly accepted method of finding out the effectiveness of the arch and surrounding tissues, including the TP, is by performing a ND test.^{37, 41, 42} Most researchers state that a drop greater than 10 mm denotes weakness going back to a

study by Mueller suggesting that a change in vertical navicular height of greater than 10 mm is considered abnormal and may be a contributing factor to foot pathology.²²

Hunt and Smith found in their EMG study that those in the pes planus group had less forefoot adduction at toe-off, and less total transverse plane range of motion. They also found that the peak force of the plantar flexors and invertors at push-off were greater than those with normal alignment.⁴³ This suggests that the ground forces during stance and motion are greater in those with pes planus feet. Pes planus can possibly lead to excess pronation and contribute to MTSS.

Commensurately, various solutions to address the pathology of foot pronation have emerged. These solutions include generic insole products, custom orthotics, and a variety of taping techniques. Success of each solution varies. Thacker demonstrated that shock-absorbing insoles reduced pronation and the incidence of MTSS.³⁵ While previous studies^{5,44} found that prescription/ custom orthotics can completely relieve symptoms. Hubbard found that over 50 % of the MTSS group wore orthotics and found it an effective modality to lessen pain. Hubbard states that the prescription of orthotics for the treatment of MTSS is effective at relieving all reported symptoms. It is also beneficial because it will not lose its tautness over time as tape has proven to do.⁵ Though custom and over the counter orthotic insoles have been used effectively, taping may be a better option in some cases.

Over the years, many taping techniques have been used to either prevent or treat MTSS. Certain techniques were used to address previously held beliefs not associated with foot pronation and therefore will not be discussed in this paper. Only those taping

techniques related to the structures and functioning of foot pronation particularly in its deceleration phase will be examined.

Taping Techniques

Vicenzino states “a reduction in symptoms when the antipronation technique is used is thought to confirm the association between excessive pronation and the patients symptoms.”³⁷ There are several taping methods that have been tested, a few of which will be discussed. The first is the LowDye technique. It is accomplished by a spur being attached on the medial aspect of the foot and wrapped around the foot to the adjacent side followed by mini stirrups going from the lateral side of the foot on the spur to the medial side on the spur (Appendix A: Figure 1).^{17,18} The reverse six technique is accomplished by laying down one anchor around the shaft of the lower leg followed by three strips of tape that lay across the top of the foot medial to lateral, cross under the foot lateral to medial and back up the medial side crossing the anterior portion of the ankle joint (Appendix A: Figure 2).^{17,18} The calcaneal sling technique is done by laying down one anchor strip followed by two strips that start on the anterior tibia and follow a pattern distally and just anterior to the medial malleolus continuing under the foot, and around the calcaneus and back up to the anchor strip (Appendix A: Figure 3).^{17,18}

The ALD taping technique is a combination of the LowDye, three reverse sixes, and two calcaneal slings (figure 4). The ALD tape technique is considered the golden standard by effectively performing better compared to other taping techniques.³⁷

The AP technique is a new technique presented by the researchers. It consists of a single piece of pre-tape that starts on the lateral foot, just anterior to the lateral malleolus. It crosses under the foot and crosses the medial foot at the navicular tubercle and anterior calcaneus. It then covers the medial malleolus and spirals across the leg to the shaft of the fibula. Two pieces of tape are administered in a similar fashion with the strips overlapping by a half an inch. These strips are pulled taught while crossing under the foot to put the foot in an inverted position (Appendix A: Figure 5). An anchor strip is applied to hold the strip down.

Tape type

Most recent studies testing the ALD taping procedures were performed with a rigid zinc oxide tape. For this study both the ALD and AP taping techniques were tested using Leukotape (BSN medical, Inc. Charlotte, North Carolina), which is a rigid rayon backed tape with aggressive zinc oxide adhesive.

Conclusion

The research has covered the causes of MTSS in great depth and has delivered many theories to its presence among several populations. One particular theory, the eccentric contraction of the soleus and TP, is most pertinent to this study.^{39,4}

Methodology

Design

This is a 2 (tape techniques) by 3 (time: baseline, tape/pre-exercise, and tape/post-exercise) controlled laboratory study design with all participants acting as their own controls.

Participants

No fewer than twenty (10 males and 10 females) symptomatic (ND \geq 10 mm) college-age (ages 18-26) students from a large university in the western United States will participate in this study. All participants must be ambulatory (able to walk for 15minutes) and free from lower-leg injury or pain within the previous month. Other exclusions will include any lower limb injuries that have happened in the last month. All participants will fill out a letter of informed consent. All procedures will receive university IRB approval. Participants will be recruited via posted announcements and personal invitation.

This sample size was determined by comparing to other studies with similar methodologies or subject matter.^{17, 29, 36, 37, 45}

Instrumentation

The ND test will also be used and will be determined with a ruler, index card, and pen, according to DeLacerda.²⁴ This is a valid and reliable intra-tester measure according Mueller et al.²²

The Tekscan pressure mat (Tekscan, Inc., South Boston, Massachusetts), called the MatScan is embedded with 8,448 electronic sensors, which are used in conjunction with computer hardware and software to get center of pressure readings throughout the stance phase of the gait cycle. This system has been found to be both a valid and reliable analysis tool.²³

Procedures

In advance of the proposed study, preliminary trials were conducted to (a)

determine the most suitable type of tape to be used with the anti-pronation tape technique, and (b) refine and standardize all study procedures. Three different tape types were tested to determine which would be more suitable for this the new taping technique (white athletic tape, elasticon, and Leukotape.) Leukotape, having consistently yielded the greatest reduction in ND, was selected for use in this study. The primary researcher, spent time sufficient to refine all study procedures such as taping technique consistency, testing procedures using the TekScan technologies, data collection procedures, and data reduction techniques. A Quinton Q65 Series 90 Treadmill (Quinton Instrument Co., Bothell, WA, U.S.A.) will be used. The participants will walk at a speed of 3.0 mph at a 0% grade for 15 minutes. This will be done unshod. No pressure data will be collected during this time.

Measurements. The ND will be tested according to the following procedure reported by DeLacerda.²⁴ The patient will be sitting with both feet on the floor, in a non-weight bearing position. The tester will palpate the medial aspect of each foot and find the navicular prominence. Using a pen, the tester will make a mark on the patient's skin at the point of the navicular prominence. Next, the tester will stand the card on the floor next to the medial arch of the foot and mark the card at the level of the navicular prominence. Next, the patient will stand. Once the arch is weight bearing, the tester will then make a second mark on the same side of the card at the new level of the navicular prominence. This procedure will be repeated with the other foot and measure the difference between the two marks for each foot. A difference of greater than 10 mm will be considered symptomatic.²⁵

Center of pressure (COP) measurements will be collected using the TekScan Technology by the following procedure. The I-scan system will be used. For this experiment the pressure mat scan rate will be set at 100Hz yielding a two-dimensional movie image of a foot strike from heel to toe and medial to lateral borders (i.e., a foot print), detected by its sensors. (See Figure 7)

A total of five images of participants foot strikes will be recorded as follows: Participants will practice to determine the appropriate distance that will require five walking steps with the fifth step striking the mat. A mark on the floor will indicate the starting point for each of their five trials. The participants will be told to walk at a comfortable walking speed and focus on a picture on the adjacent wall to ensure gait will be as normal as possible.

Intervention. The taping techniques order will counter balanced. Data will be collected over two similar one-hour sessions by the primary researcher as follows.

1. Upon arrival at the testing facility, participants will fill out a survey designed to collect demographic and other pertinent data (e.g., age, gender, height, weight, history, activity patterns, etc.)
2. Data specific to the pressure mat software will be entered into the computer.
3. Next, unshod participants will be measured with respect to (a) ND (average of three measurements) and (b) center of pressure (average of five, foot strikes per foot).

4. Next, participants will be taped according to above procedures, by the same person and both measurements repeated.
5. A break-in period of time will be done to determine the effectiveness of the tape techniques after and exercise bout. According to Paris, Vardaxis and Kokkaliaris⁴⁶ tape loosens after a 15-minute bout of exercise. We will use this standard for our break-in period. Participants will then walk on a treadmill for fifteen minutes at a pre-determined speed of 3.0 mph at 0% grade on a Quinton Q65 Series 90 Treadmill (Quinton Instrument Co., Bothell, WA, U.S.A.).
6. After the break-in period both measures will again be taken using the same protocol.
7. Within three weeks, session two will employ the same procedures described above.

The following taping procedures will be used. The augmented LowDye taping technique is a combination of the LowDye, three reverse sixes, and two calcaneal slings. Figure can be found in the appendix (Figure 1). The LowDye technique is accomplished by a spur being attached on the medial aspect of the foot and wrapped around the foot to the adjacent side followed by mini stirrups going from the lateral side of the foot on the spur to the medial side on the spur (Figure 2). The reverse sixes is accomplished by laying down anchors followed by three strips of tape that lay across the top of the foot medial to lateral, cross under the foot lateral to medial and back up the medial side crossing the anterior portion of the ankle joint (Figure 3). The calcaneal sling technique

is done by the laying down of anchor strips followed by two strips that start on the anterior tibia and follow a pattern distally and just anterior to the medial malleolus continuing under the foot, and around the calcaneus and back up to the anchor strip (Figure 4). No pre-wrap will be applied with this tape procedure.

The anti-pronation technique consists of a single piece of pre-tape that starts on the lateral foot, just anterior to the lateral malleolus. It crosses under the foot and crosses the medial foot at the navicular tubercle and anterior calcaneus. It then covers the medial malleolus and spirals across the leg to the shaft of the fibula. Then two pieces of tape will be administered in a similar fashion with the strips overlapping by a half an inch. These strips will be pulled taught while crossing under the foot to put the foot in an inverted position (Figures 5 and 6). An anchor strip will be applied to hold the strip down.

The tape type that will be used in this experiment is Leukotape P Sports Tape, which is rayon-backed tape with an aggressive zinc oxide adhesive. It will be purchased in 1 ½" x 15 yard rolls (BSN medical, Inc. Charlotte, North Carolina). The Leukotape will be used in conjunction with Cover-Roll Stretch, to aid in skin protection in the anti-pronation tape technique. This is a 4" x 10 Yards Non-Woven Adhesive Bandage that is hypoallergenic, self-adhesive, air-permeable, and cross elastic (BSN medical, Inc. Charlotte, North Carolina). Pre-tape spray will be used with both tape techniques.

Data Collection and Analysis

Demographic data (height, weight, health, physical activity level, uses of orthotics, lower limb surgery/therapy/injury, gender, etc.) will be collected via an initial

questionnaire. Stance (i.e., surface area from heel strike to toe off and from medial to lateral borders) will be measured using the pressure mat. It will, however, be impossible to assure that each stance profile will occur at exactly the same position on the pressure mat necessitating data standardizing techniques to be applied to the mat-yielded, raw data points.

Data Analysis. The stance phase, visually illustrated by the software program, includes COP measurements from each of five samples throughout the stance and generates a line representing the COP throughout the foot strike. This COP line will be time normalized to 100 data points.

The COP in the heel strike will be the first reference point and the peak-pressure-point in the toe-off phase represents the second reference point. A third reference point (located at the medial boarder of the big toe during the peak pressure in the toe off phase) will be established. A reference line will be drawn between the first and the third reference point. To accommodate for differences in time sequences (due to differences in foot size and contact time), all data will be normalized to equal 100 data points. All subsequent analyses will then be performed using this normalized data. This will be repeated for each sample (see Figure 7 and 8 in Appendix). The distance from the COP line to the reference line will be determined with the point-line equation by Weisstein⁴⁷ in Figure 9 (see Appendix).

A series of functional analyses will be used to assess the between group (tape techniques) and within (times) differences as well as perceptual data. This analysis will observe a stance phase as a polynomial function rather than a discrete data point,

allowing for an observation of where differences exist during stance.

All data will be input into SPSS and will be inspected for any data input errors. Descriptive data will be computed as appropriate to examine means, standard deviations, frequencies, etc. A two (tape techniques) by three (time) ANOVA will be used to test between and within group differences in ND and lateral excursion of the COP.

Independent and Dependent Variables. The independent variables are the tape techniques (control, ALD and Anti-pronation) and time (baseline, tape pre-exercise, tape post-exercise). Possible confounding variables (demographic variables, listed in the appendix) will be treated as covariates and statistically controlled. Since this study only includes adult physically active population, the generalizability of the results will be limited to a population of similar age and fitness level. The dependent variables include vertical difference in navicular height measured in mm, MatScan COP lines, over four times (baseline, tape pre-exercise, tape post-exercise).

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Appendix A

Questionnaire

History Questionnaire

1. Name:
2. Height (inches):
3. Weight (pounds):
4. Do you consider yourself in good health?
5. What is your physical activity level (days per week):
6. Do you wear custom orthotic inserts:
7. Have you had a lower limb surgery in the last year?
8. Have you had a lower limb physical therapy in the last 6 months?
9. Have you had a lower limb injury within the last month?

Figures



Figure 14- LowDye Tape Technique (Medial View)



Figure 15- LowDye Tape Technique (Medial View Partial Weight Bearing)



Figure 16- Low Dye Tape Technique (Lateral View).It is accomplished by a spur being attached on the medial aspect of the foot and wrapped around the foot to the adjacent side followed by mini stirrups going from the lateral side of the foot on the spur to the medial side on the spur



Figure 17- Reverse Sixes Tape Technique (Medial View)



Figure 18- Reverse Sixes Tape Technique (Medial View Partial Weight Bearing)



Figure 19- Reverse Sixes Tape Technique (Lateral View). It is accomplished by laying down anchors followed by three strips of tape that lay across the top of the foot medial to lateral, cross under the foot lateral to medial and back up the medial side crossing the anterior portion of the ankle joint



Figure 20- Calcaneal Sling Tape Technique (Medial View)



Figure 21- Calcaneal Sling Tape Technique (Medial View Partial Weight Bearing)



Figure 22- Calcaneal Sling Tape Technique (Lateral View). It is done by laying down one anchor strip followed by two strips that start on the anterior tibia and follow a pattern distally and just anterior to the medial malleolus continuing under the foot, and around the calcaneus and back up to the anchor strip



Figure 23- Augmented LowDye Tape Technique (Medial View)

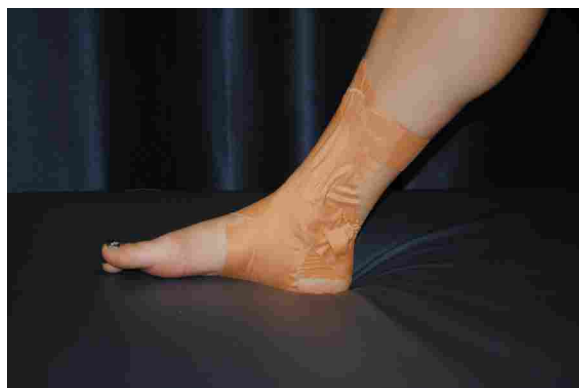


Figure 24- Augmented LowDye Tape Technique (Medial View Partial Weight Bearing)



Figure 25- Augmented LowDye Tape Technique (Lateral View). It is a combination of the LowDye, three reverse sixes, and two calcaneal slings.



Figure 26- Anti-Pronation Tape Technique (Medial View)



Figure 27- Anti-Pronation Tape Technique (Lateral View). It consists of a single piece of pre-tape that starts on the lateral foot, just anterior to the lateral malleolus. It crosses under the foot and crosses the medial foot at the navicular tubercle and anterior calcaneus. It then covers the medial malleolus and spirals across the leg to the shaft of the fibula. Two pieces of tape are administered in a similar fashion with the strips overlapping by a half an inch. These strips are pulled taut while crossing under the foot to put the foot in an inverted position. An anchor strip is applied to hold the strip down.

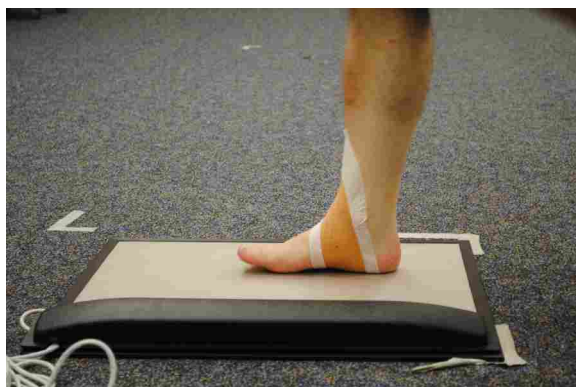


Figure 28- Walking across MatScan Mat in AP Tape Technique (Medial View)

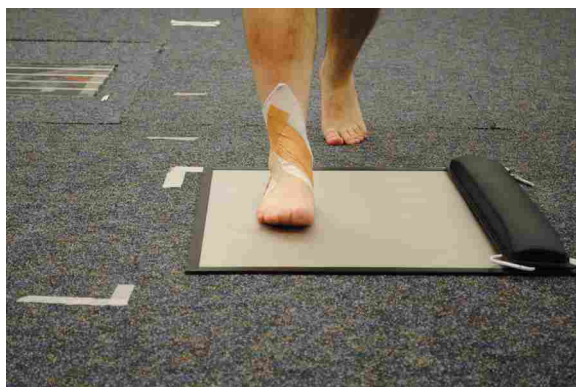


Figure 29- Walking across MatScan Mat in AP Tape Technique (Front View)

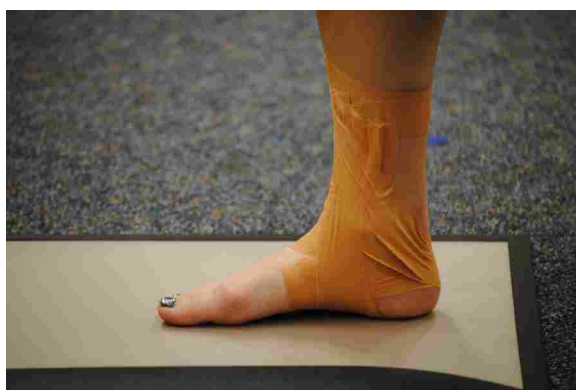


Figure 30- Walking across MatScan Mat in ALD Tape Technique (Medial View)

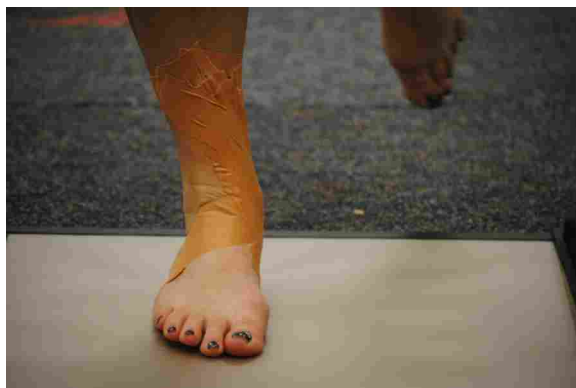


Figure 31- Walking across MatScan Mat in ALD Tape Technique (Front View)