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The Effects of a Dynamic Warm-up on Low-Dye Taping in Pronated Participants

Trevor Daniel Aukerman
Grand Valley State University

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Context: The low-dye taping (LDT) is a commonly used method that is intended to prevent overpronation and support the medial longitudinal arch (MLA) of the foot. There is limited investigation into the effectiveness of the LDT after dynamic, multiplanar exercises, and if the LDT's effectiveness is affected by the degree of foot pronation.

Objective: Determine if the LDT is effective after a dynamic warm-up and if the degree of the taping's effectiveness is changed with the severity of foot pronation.

Design: Cross-sectional study

Setting: Multipurpose court

Patients or Other Participants: Thirty-four participants (26 women, 8 men; age=21.4±1.9; height=167.0±9.0cm, weight=67.6±14.3kg) with a Foot Posture Index-6 (FPI-6) score of ≥+5.

Intervention: All participants completed a dynamic warm-up routine where dorsal arch heights (DAH) were collected before being taped, after being taped, and after the warm-up routine.

Main Outcome Measure(s): The dependent variables were the changes in DAH for the three different timeframes and participants were placed in either a 'pronated' or 'highly pronated' subgroup based on their FPI-6 scores. Separate one-way repeated measures ANOVAs were used to determine the LDT effectiveness over time and a two-way repeated-measures ANCOVA, with FPI-6 scores as a covariate, was also conducted.

Results: A one-way repeated measures ANOVA revealed that there was a significant difference in mean DAHs for the taping time points ($p<0.001$). Using a post hoc paired samples T-test, there were significant differences in DAHs between pre-taping and post taping ($p<0.001$), and pre-taping and post-dynamic warm-up ($p<0.001$). However, there was no significant difference between DAHs for post-taping and post-dynamic warm-up ($p=0.08$). A two-way repeated-measures ANCOVA revealed that there were no significant differences in DAHs for the 'pronated' and 'highly pronated' subgroups ($p=0.92$).

Conclusion: Results of the current study show that the LDT was effective in supporting the MLA of participants with pronated foot postures following a dynamic warm-up and the degree of pronation did not alter its effectiveness.

Key Words: low-dye taping, arch support, dynamic warm-up, pronation

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Key Points

- The LDT was considered effective in supporting the medial longitudinal arch of the foot following a dynamic warm-up.
- The degree of pronated static foot posture did not change the effectiveness of the low-dye taping.
- Longer durations of multiplanar exercises may be needed to assess the low-dye taping effectiveness over a longer period of time to reflect demands similar to athletic competition.

While many athletic trainers regularly use taping techniques to increase joint stability or to prevent injury or reinjury, questions remain on the maintained effectiveness of these tapings over an acute bout of exercise. Increased perspiration and heat, as a result of physical activity, often cause the tape to lose its rigidity and adhesiveness. As a result, many clinicians opt to use braces, orthotics, or alternative taping materials for improved confidence in resilience. However, while the debate of taping versus bracing or orthoses continues, taping within the athletic environment will continue to be common practice due to its convenience and temporary solution in prevention or treatment for musculoskeletal injuries. Therefore, a better understanding of traditional white non-elastic tapes resiliency is needed.

The function of the low-dye taping (LDT) technique is to support the medial longitudinal arch (MLA) of the foot in order to prevent overpronation. Overpronation or pronation occurs at the joints interactions between the talocrural, subtalar, midtarsal, and distal tibiofibular syndesmosis in the lower extremity.[1] This complex movement of the lower foot is a result of no muscular attachments to the talus, causing the stability of the subtalar joint to derive from bony and ligamentous restraints. The foot and ankle influence the biomechanics of the tibia, femorotibial, and acetabulofemoral joint and an increase in pronation leads to an increase in tibial rotation, hip internal rotation, and knee flexion. Past research has suggested that overpronation is the primary cause of several overuse injuries such as medial tibial stress syndrome, plantar fasciitis, Achilles tendonitis, and patellofemoral pain syndrome.[2] Moreover, it is believed that overpronation is the cause of 60-90% of all lower extremity overuse injuries.[3] This is due to the lower extremity’s inability to properly transition to a supinated position, which creates a lever to propel the foot forward and disperse the ground reaction forces evenly throughout the foot.[4,5]

In sports, it is common for athletes to get taped prior to performing their warm-up routine. While there has been previous research investigating the effectiveness of the LDT in supporting the MLA immediately after taping and after prolonged continuous activity, there is no investigation into the tapings' effectiveness at supporting the MLA after a dynamic warm-up. Consequently, research is needed to investigate the resiliency of white tape following a dynamic warm-up in order to determine if the tape remains effective for the practice or athletic event to follow. Therefore the purpose of this study is to explore the effects of the LDT on the dorsal arch heights (DAH) before and after a dynamic warm-up, as well as determine if the LDT is impacted based on the severity of pronation from participants' static foot posture.

METHODS

Study Design

In this cross-sectional study, all participants were required to participate in a single dynamic warm-up session where they received the LDT. All testing sessions occurred between the hours of 12-4 pm to control for foot volume fluctuations that normally occur throughout the day. All data collection took place on a basketball court to standardize the distances of the exercises and testing surface. Additionally, participants performed the warm-up exercises without their shoes on to limit the effects that shoes may have in aiding the support of the arch. Each participant performed the same dynamic warm-up exercises, with both verbal and visual instructions given by the clinician on how to perform the movements correctly (Table 1). The dynamic warmup routine was created with university strength and conditioning staff and coaches to simulate an appropriate dynamic warm-up seen within a sports practice. Participants were allowed to rest during the warm-up activity as needed, but not exceed 15 seconds between each exercise. Participants' DAHs were measured at the designated time frames before being taped (pre-tape), immediately after being taped (post-tape), and after completing the dynamic warm-up (post-dyn). The Institutional Review Board at the university approved this study and all participants signed and completed a consent and health questionnaire form before beginning participation.

Participants and Recruitment

There was a total of forty-three participants recruited via email, physical research flyer posting, and word of mouth. Inclusion criteria for this study required participants to 1) pass a physical activity readiness form, 2) be 18-45 years of age, 3) be physically present at the intervention session, 4) have the ability to comprehend written and spoken English, and 5) have an FPI-6 score greater than +5. Participants were excluded from participation in this study if 1) they were diagnosed, treated, or are currently being treated for a known heart or respiratory condition, 2) had a history of losing consciousness, chest pain, or fainting during exercise, 3) had undergone major reconstructive surgery of the ankle or foot, 4) had suffered a foot or ankle injury within the last 6 months, 5) had a known allergy to adhesive spray or tape, 6) had any current bacterial or fungal infection of the foot, or 7) had any condition (bunions, unequal leg length, blisters, etc.) that may affect their biomechanics or be a contraindication for exercise.

FPI-6 Scoring Procedure

The Foot Posture Index-6 (FPI-6) has been widely used due to its quick and easy procedures to determine a person's static foot posture. Unlike other tools that measure foot posture, the FPI-6 does not require additional tools beyond clinical observation. The clinician assessing the participants' foot posture used the FPI-6 user manual which takes a series of 6 different scores to determine a person's foot posture[6]. While assessing the FPI-6 scores, participants were instructed to stand still with their feet shoulder-width apart, arms by their sides, and head looking straight ahead to minimize participant movement. Their foot posture was then scored 3 consecutive times, with their average score being used to determine their final score. In research of novice clinicians using the FPI-6, it was reported that after 3 hours of training, intra-rater reliability was 0.98.[8] Due to this study involving a tape that is intended to prevent pronation, the FPI-6 was used to establish a pronated foot posture for inclusion. Pronated participants with a foot posture score of +5.0 to +7.9 were sorted into the pronated subgroup, while those with a score of +8 to +12 were sorted into the highly pronated subgroup. These subgroups were based on previous research suggesting newer guidelines for FPI-6 score assessments and the re-classification of the two pronation subgroups.[9] The scores were used as a cut point to determine if a participant belonged to the pronated or highly pronated groups, to investigate if the LDT effectiveness was changed based on the degree of pronation. The same clinician collected all FPI-6 scoring after performing the recommended minimum 3-hours of training.[8]

Low-Dye Taping

The same clinician who assessed the FPI-6 scores also applied the LDT to the participants' dominant foot. Prior to data collection, the clinician practiced the taping technique to ensure the correct technique and consistency of application. Each participant's foot was inspected to ensure that they had no presence of foot condition that may exclude them from participation. Next, the participant's foot was cleaned with soap and warm water, thoroughly dried, and then sprayed with tape adherent for better adherence of the tape to the skin. The tape used in this study for the application of the LDT was 1.5-inch non-elastic white tape. LDT application followed traditional procedures shown in previous research investigating this taping with participants seated in a neutral position (Figure 1).[10–12]

Dorsal Arch Height Instrumentation & Procedures

Instrumentation used for measuring truncated foot length and DAH followed similar protocols seen in past research investigating overpronation.[13,15,16] The tools used for data collection for DAH measurements were a caliper, height gauge, clear platform, wax paper, and marker. An iGaging 12-inch Digital Fastener Caliper (UNSPSC code: 27110000; part number: 100-344-12) was chosen to measure the truncated foot length and an iGaging 6-inch AccuMarking Digital Gauge (UNSPSC code: 27110000; part number: 35-780) was used to measure DAHs. The manufacturer states that both devices have an accuracy of 0.0254 mm and come with a certification of calibration. For this study the units of millimeters were used in assessing both weight-bearing (WB) and non-weight-bearing (NWB) measurements for more precise measurements. These devices were selected to measure the DAH instead of using the navicular drop test due to their greater intra-rater reliability and avoidance of palpating ambiguous anatomical structures which could lead to less accurate measurements. Intra-rater reliability coefficients for a similar study investigating DAHs for WB and NWB were both 0.98, suggesting that the procedures outlined in this study can lead to accurate measurements.[13] Within this study there was one platform used for WB and NWB measurements with indicators placed on the posterior and medial portions of the wax paper covering the platform to ensure that each participant's foot was in the same location for each measurement.

For WB DAH, participants were asked to stand on a platform as the top of their dorsal arch was measured by a caliper and marked with a marker. The measurement location was determined by taking half the distance of participants' truncated foot and marking the location most superior to that point, signifying the apex of the medial longitudinal arch (Figure 2a).[13] This marked location was used as a reference point for all following DAH measurements. Next, NWB DAH was taken while participants were seated on a treatment table with their foot placed in a neutral position. This method of measuring has been used within past research as a more precise and quicker alternative than navicular drop when measuring static foot posture.[7,13,14] Both the WB and NWB DAH measurements were recorded before the patient was taped (Figures 2b and 2c). Once the data was recorded, the participant was taped and their WB and NWB DAH were taken a second time to record post-taping measurements. Finally, WB and NWB DAH were then taken a third time after the participants completed the dynamic warm-up. This procedure for DAH measurements, similar to Cornwall et al. [15] was conducted to assess the taping's effectiveness in supporting the MLA over the duration of a warm-up routine.

Statistical Analysis

Descriptive statistics were calculated to determine the height, weight, age, and average FPI-6 scores of participants included in this study. Before statistical analysis, the difference between NWB and WB DAH were taken for each time point. An ANOVA repeated measures were run to compare the mean differences between WB and NWB DAHs for the time points of pre-tape, post-tape, and post-dyn across all participants. Next, participant data was separated into pronated (+5.0 to +7.9) and highly pronated (+8 to +12) subgroups to investigate if the LDT taping effectiveness differed based on the severity of pronation. This sub-analysis was conducted using ANCOVA repeated measures with a covariant of FPI-6 score, examining for significant differences between pre-tape, post-tape, and post-dyn DAH measurements.

RESULTS

Descriptive Statistics

Of the 43 participants, 34 participants completed this study and met the inclusion criteria (n=26 women,8 men; height= 167.0±9.0cm, weight= 67.6±14.3kg, age= 21.4±1.9years, average pronated FPI-6 score=6.10±0.55, average highly pronated FPI-6 score=9.01±1.20). Upon evaluation of FPI-6 scores, 13 participants were placed in the pronated subgroup, while 21 were placed in the highly pronated subgroup.

DAH of Whole Sample

Mean values for differences in DAHs for all measurement periods were as follows: pre-tape 9.59mm (±3.19), post-tape 7.30mm (±2.48), and post-dyn 8.15mm (±2.72) (Table 2). A one-way repeated measures ANOVA revealed that there was a significant difference in DAH for the three-time points ($p<0.001$). Using a post hoc paired samples T-test, a significant difference in DAH was found between pre-tape and post-tape (mean differences 2.29±2.56mm, $p<0.001$) and pre-tape and post-dyn (mean differences 1.44±2.24mm, $p<0.001$). However, no significant differences were found between mean DAH measurements for post-tape and post-dyn (mean differences -0.84±2.76mm, $p=0.08$). Tables for post-hoc pairwise comparisons can be found in Table 3. Data for matched FPI-6, WB and NWB DAH can be found in Table 4.

DAH of Pronation Groupings

Using a two-way repeated-measures ANCOVA with a covariate of FPI-6 scores, there were no significant differences found for mean DAHs between the ‘pronated’ and 'highly pronated’ subgroups ($p=0.92$) (Table 5). Mean values for changes in DAHs for the pronated and highly pronated subgroups can be found in Table 5.

DISCUSSION

Based on the results of the study we concluded that the LDT was effective in supporting the MLA of the foot throughout the dynamic warm-up. We found that there were no statistical differences between mean DAHs for post-taping and post-dynamic warm-up which would suggest that the LDT prevented over-pronation in participants with a pronated foot posture. The secondary aim of the current study was to assess if the severity of pronation affected the tapes resiliency through the dynamic warm-up routine. We found that there were no statistical differences between the pronated and highly pronated groups, suggesting that the LDT was not affected by the degree of static pronated foot postures.

The results of this study align with previous research investigating the LDT for shorter durations. In previous studies, DAHs were found to be increased by 3.8mm[17], 4.0mm[18], and 7.2mm[19] during exercise timeframes of less than 20 minutes. Each of these studies provided sufficient evidence that the LDT remained effective throughout short bouts of exercise, however they only investigated the changes of the DAH in the WB position rather than changes from the NWB to WB positions as was conducted in this study. An increase in DAH in the WB position would suggest that the tape was effective in maintaining or increasing the height of the MLA. Whereas in our study, measuring DAH in WB and NWB allows us to investigate the movement of the MLA more accurately, as the foot is arched in NWB and collapsed in WB. Based on the results of our study, the LDT was found to be effective in supporting the MLA between the two positions providing further support for this taping use for short duration activities.

When investigating the LDT over longer durations, Cornwall et al.[15] and Abian et al.[20] discovered that the LDT remained effective for over 20 minutes of use. Within Abian et al.[20] patients were asked to exercise for 30 minutes, including jogging and jumping vertically in place. Whereas, in Cornwall et al.[15] participants were required to wear the prophylactic tapings for four hours before and after a 2-mile jog. Within both studies WB DAH were increased by an average of 3.1mm after exercise, providing evidence that the taping remained effective.[15,20] However, both studies involved the use of a modified LDT with elastic tape and the application of strappings that crossed the talocrural joint, differing from our own application of the LDT. While these studies added the additional strap across the talocrural joint and had participants exercise for longer durations, they both failed to investigate multiplanar movements as is commonly seen in athletics, which would place varying stresses on the tape. The use of dynamic movements in our warm-up routine allowed us to investigate stressors that are more commonplace to movements in sports, and we found that the LDT was effective post dynamic warm-up. However, the ability of LDT to maintain DAH while performing these multiplanar movements for longer durations remains to be investigated.

When assessing the efficacy of the LDT, it is hard to draw conclusive evidence indicating its effectiveness throughout a practice or physical activity. Many studies assessing LDT vary in their application and the materials used. Three previous studies closely resembled our application of the LDT.[10-12] However, only two studies used non-elastic white tape as we did.[10,12] Comparing the results of these studies to that of our study we found contrasting results. Vicenzino et al.[12] found a decrease of

14.1mm of vertical navicular height drop after 10 minutes of jogging. This would suggest that the decrease in vertical navicular height drop would mean increased pressure on the midfoot, leading to an increase in pronation with the LDT. Likewise, Newell et al.[10] found that the LDT was ineffective in decreasing navicular drop in pronated participants following 15 minutes of barefoot jogging. However, an interesting finding of this study was a shift in medial to lateral midfoot pressure and an increase in forefoot pressure found with the LDT.[10] This shift in lateral midfoot pressure and forefoot pressure would suggest that while navicular drop was not decreased, there was evidence suggesting over-pronation may have been limited using planar pressure measurements. In previous LDT research, an increase in forefoot pressure and an increase in lateral midfoot pressure has been linked to increased toe flexor and extensor activation during the propulsion phase of gait.[21] These changes in pressure allow for the foot to fully take advantage of the windlass effect, in which pressure is shifted from the lateral portions of the midfoot to the forefoot allowing for the proper stretch-shortening cycle to occur in the plantar fascia.[21] This restoration of normal kinematics would decrease the amount of pronation participants would have. Similar to the results found within our study, with DAHs not being statistically different from post-taping to post dynamic warm-up, the LDT was effective in preventing overpronation and maintained throughout physical activity. So while the results of the previous studies differ from measurement outcomes assessing the effectiveness of the LDT, Newell et al.[10] findings would suggest that the LDT was effective in preventing overpronation.

We found there was a trend in both subgroups in which the DAHs decreased from pre-taping to post-taping levels, but there was a slight increase in mean differences in DAH from post-taping to post-dynamic warm-up (Table 3). This suggests that the LDTs effectiveness in preventing overpronation diminished slightly. While not statistically significant, it is important to note this trend as previous research has suggested that after 20 minutes of exercise non-elastic white tape significantly loses its effectiveness.[11,19,23] Non-elastic white tape loses its tensile strength as the participant engages in athletic movements that stress it, as well as its adherence to the skin decreases as body temperature increases and sweating ensues.[17,19] This would indicate that reassessment or re-application of the LDT may be needed during longer intervals of exercise. However, this is an assumption based on the results of the LDT's effectiveness following a dynamic warm-up and future research is needed to explore this further, making recommendations.

Clinical Implications

Taping is not meant to be a long-term solution for preventive or corrective purposes, but if tape provides the desired effects then a clinician should consider it a successful outcome. Within this study, the LDT was successful in reducing the amount of pronation from a static foot posture standpoint. While the study investigated the LDT effectiveness indirectly via DAHs, clinicians should still feel confident using the LDT to temporarily aid in preventing overpronation and injuries that may result from overpronation. Previous research has shown that the use of orthoses in combination with the LDT, or another over-pronation taping, may provide additional support to the MLA for longer durations.[19] However, if a patient presents with a chronic inability to control pronation, an intervention such as taping or orthoses cannot correct this problem.[17] In this case, clinicians should opt for designing a rehabilitation program that focuses on building foot intrinsic muscular strength and proprioception to take advantage of the windlass effect of the foot.[2,22]

An important finding within this research was that there were no statistical differences between the pronated and highly pronated subgroups. This suggests that the degree of a patient's static pronated foot posture does not significantly change the effectiveness of the LDT, allowing clinicians to feel confident in using it for preventing overpronation regardless of severity. While the mean differences in DAH increased from post-taping to post-dynamic warm-up, the differences did not reach statistical significance. However, clinicians should be prudent with the use of the LDT for longer periods of time, as the LDT's usefulness in preventing overpronation may diminish over time, due to the tape losing resiliency. With that being said, the results found within our study should provide clinicians confidence that the LDT can maintain the support of the MLA following a dynamic warm-up. This is an important and useful finding as clinicians often opt to tape their patients before they begin their warm-up prior to practice or competition in which the MLA support will be needed to prevent injuries.

Limitations

Even with careful planning, this study was not free of limitations. Although a single clinician performed all the LDT for participants, one limitation was the potential variance in clinician tape application. Though this clinician had practiced to be proficient in applying the LDT, intra-rater reliability was not evaluated for applying the LDT. Coincidentally, all participants included in this study answered that they were right foot dominant, thus the tape was applied to their right foot. As a result, this study failed to investigate persons who are left foot dominant. Another limitation was that there was no blinding or randomization done to limit bias. The same clinician measured participants' FPI-6 scores, applied the LDT, and measured DAHs. This could potentially lead to unintentional bias during the testing session. However, in an attempt to limit bias, the DAH differences and sorting of participants into the 'pronated' and 'highly pronated' subgroups was not done until after the participant finished the dynamic warm-up. A final limitation was the decision to have participants complete the testing session without wearing shoes or socks. This was done to control for the impact various shoe and sock varieties may have in supporting the foot so that the LDT's effectiveness could be isolated. While this was considered necessary by the researchers, it could have led to participants altering their gait patterns during the dynamic warm-up exercises in accommodation to this unaccustomed condition.

Areas of Future Research

Future studies should further investigate the traditional application style of the LDT, seen within this study, but with elastic and non-elastic tape or a combination of orthoses and the LDT. Doing so would allow clinicians a better understanding of how the LDT's effectiveness may be changed with the use of other taping materials or orthoses. Additionally, future studies should consider using rearfoot motion analysis or plantar pressure measurements while participants are exercising to truly investigate the LDT's effectiveness at preventing over-pronation during an exercise intervention. Unfortunately, within this study and previous taping research, the tapings effectiveness is only measured at timed intervals where items like DAH or navicular drop are used to assess the tape's effectiveness pre and post-exercise. Using real-time motion analysis or plantar pressure would be beneficial in progressing taping research and knowledge of how tape affects the biomechanics of participants during exercise. As mentioned previously every participant included in this study was right foot dominant and had the taping applied to their right foot. Future studies should investigate if the results found within this study align with results found in taping a participant's non-dominant foot. This would explore if there were changes in the forces applied to the tape based on dominant versus non-dominant foot, and thus differences in the tape's resiliency. Lastly, future studies should replicate the procedures found within this study but have participants exercise for longer periods of time to validate the assumption that the LDT’s effectiveness diminishes with more time, as well as determine at what point the LDT becomes ineffective. This would provide practitioners with working knowledge of when the appropriate time for reapplication of the LDT should occur.

CONCLUSIONS

To the researchers’ knowledge, this is the first study to investigate the effectiveness of the traditional LDT application on pronated participants completing a dynamic warm-up. Based on the results of this study, the LDT remained effective in supporting the MLA of the foot throughout the dynamic warm-up routine, with no differences found between pronated and highly pronated subgroups. This would indicate that the application of the LDT prior to a dynamic warm-up routine, or short-term multiplanar movements, will not compromise its effectiveness. While there was a slight increase in mean DAH differences from post-taping to post-dynamic warm-up, suggesting the LDT’s effectiveness diminished slightly, it did not reach statistical significance. With the outcomes of the current study, clinicians can feel confident that taping a patient prior to warm-up will not compromise the overall integrity of the LDT in limiting overpronation. Future research is needed to investigate longer-duration activities in order to better understand LDT resilience and the duration at which it is ineffective at providing the support needed for the MLA.

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