Effect of a Modified, Low-Dye Medial Longitudinal Arch Taping Procedure on the Subtalar Joint Neutral Position Before and After Light Exercise

Clayton F. Holmes, PT, EdD, ATC[1]
Donald Wilcox, PT, MS[2]
James P. Fletcher, PT, MS, ATC[3]

Study Design: Single-group repeated measures design pre- and postintervention.
Objectives: To determine if the modified low-Dye medial longitudinal arch (MLA) taping procedure places the subtalar joint into the neutral position and maintains the subtalar joint neutral (STJN) position following 10 minutes of walking.
Background: Subtalar malalignment in excessive pronation is commonly accepted as a contributing factor to a variety of musculoskeletal pathologies. The modified low-Dye MLA taping procedure is often used on the plantar surface of the foot as a short-term corrective tool for excessive foot pronation. However, research that evaluates the efficacy of this taping technique during light exercise is lacking. Measurement of navicular height is commonly used as a measure of subtalar position.
Methods and Measures: Prior to the study, one tester-established reliability in the navicular drop technique measurement by initially practicing the measurements on 400 feet, followed by a reliability study performed on 29 subjects. In this study, a screening procedure excluded subjects with ankle or foot pathology, supinated feet, or neutral feet, and included only subjects with pronated feet. The study, which included 40 subjects, involved four steps: (1) measuring navicular height in the relaxed position; (2) measuring navicular height in the STJN position; (3) measuring navicular height after application of the modified low-Dye MLA taping procedure; and (4) measuring navicular height after subjects had walked for 10 minutes with the taping.
Results: Results indicated an intrarater intraclass correlation coefficient (ICC) for measuring navicular height of 0.96 for the right foot and 0.94 for the left foot. Repeated measures ANOVA revealed that significant differences existed ($P < 0.05$) among the 4 measures. A Bonferroni post hoc analysis showed a difference between relaxed stance measurements and all other measurements, and between taped-prewalking measurements and taped-postwalking measurements. In addition, no significant difference was observed between navicular height measured in STJN and the taped-prewalking and taped-postwalking conditions. The average navicular height for the taped-prewalking condition was 1.6 mm higher than that for the STJN position. For the taped-postwalking condition, the average height of the navicular was 1.2 mm lower than that of the STJN position.
Conclusion: These results demonstrate that the modified low-Dye MLA taping procedure places the subtalar joint near the neutral position. Despite a significant reduction in the height of the navicular after the subjects walked for 10 minutes with the tape on, the height of the navicular was still not significantly different than that of the STJN position. *J Orthop Sports Phys Ther 2002;32:194–201.*

Key Words: *medial longitudinal arch, navicular height, pronation, subtalar joint*

The subtalar joint neutral (STJN) position is described by Elveru et al[4] as the position at which the subtalar joint is neither pronated nor supinated. Biomechanical analysis and treatment of biomechanical disorders of the foot and lower extremity are often based on the theoretical existence of the STJN. The underlying assumption is that the weight-bearing foot will be more efficient and less prone to injury if the subtalar joint's range of movement and function is close to its neutral position, as opposed to abnormally pronated or supinated.[1,4,9,14] Some have questioned the actual existence of the

[1] *Associate professor, Department of Physical Therapy, University of Central Arkansas, Conway, AR.*
[2] *Practicing physical therapist, director, St. Bernard Outpatient Physical Therapy, Paragould, AR.*
[3] *Clinical instructor II, Department of Physical Therapy, University of Central Arkansas, Conway, AR.*
The University of Central Arkansas Institutional Review Board approved the protocol for this study.
Send correspondence to Clayton F. Holmes, University of Central Arkansas, Physical Therapy Center, Room 319, 201 Donaghey Avenue, Conway, AR 72035-0001. E-mail: holmesc@mail.uca.edu

STJN position.[9] However, regardless of its existence, the position of STJN remains a common reference point that has been described repeatedly in the literature.[1,3,4,9–11,17] The STJN position can be determined through clinical palpation and may therefore be used to determine the effect of a specific intervention on the relative position of the foot.

Prolonged pronation of the subtalar joint may be associated with injuries of the lower extremities such as patellofemoral pain, sacroiliac pain, and low back pain.[8,11,16] Physical therapists, athletic trainers, and podiatrists need to be able to identify subtalar malalignment so that interventions such as taping procedures and orthotics can be prescribed for correction.

Though clinicians have used short-term taping as a diagnostic tool for palliative purposes while waiting on the proper orthotic device, few studies have evaluated the effect of ankle or foot taping on the correction of subtalar joint malalignments.[6,19] Wilkerson[19] proposed a modification of the standard method of ankle taping that is common to athletics. The modification involved the addition of a talar sling, which introduced a supination pull on the forefoot. Though the modification was initially effective, the taping technique had lost its effect after a 2-hour football practice. Greene and Hillman[6] observed that maximal losses in taping restriction for standard athletic ankle taping occurred in the first 20 minutes of a 3-hour volleyball practice.

Ator et al[2] studied the effects of "double-X" taping and modified low-Dye medial longitudinal arch (MLA) taping procedures on the ability to support the MLA before and after 10 minutes of jogging. Measurement of navicular height from the floor was used for data collection and comparison. However, no reference was made to the subtalar joint or its neutral position. Both taping procedures initially changed the height of the navicular. After 10 minutes of jogging, the height of the navicular was nearly the same as when measured with the subjects barefoot prior to the application of tape.

The standard low-Dye MLA taping procedure has long been used to correct pronation and symptomatic pes planus ("flat feet"). A modified taping technique derived from the standard low-Dye MLA taping technique was proposed by Schulties and Draper.[16] Modifications consisted of an opposite pull of tape from medial to lateral across the plantar surface of the rear foot and from lateral to medial across the forefoot. These modifications enhanced the ability of the low-Dye taping procedure to correct excessive pronation. However, no published study has yet evaluated the efficacy of this taping technique.

Determining the neutral position of the subtalar joint is a very important measure for evaluation and treatment of orthopaedic and sports injuries and dysfunctions.[11,13,16] Many different methods have been proposed for accurate measurement of this theoretical position, which represents the midpoint between subtalar pronation and supination. In 1977, Root et al[15] proposed a method of calculating the STJN position from inversion and eversion of the subtalar joint using a protractor. The calculation was based on the theoretical 2:1 ratio of supination to pronation. However, the technique proved to be time consuming and cumbersome and lacked theoretical soundness.[4] Wernick and Langer[18] proposed a non–weight-bearing method that required the examiner to palpate the medial and lateral aspects of the head of the talus with the patient lying in a prone position. When the talus protruded equally on both sides, the joint was considered to be in the neutral position. Calcaneal angle (angle between the midline of the calcaneus and the posterior aspect of the distal lower leg) measurements were then taken with a goniometer while the foot was held in the STJN position. This method has been the most common method of determining the STJN position clinically.[4] Small modifications have been proposed by James et al,[7] McPoil and Brocato,[9] and Elveru et al.[4] However, the technique is essentially the same. The highest reported intrarater reliability using intraclass correlation coefficients (ICC) was 0.77, with an interrater reliability of 0.25.[3]

Because of the difficulties in obtaining reliable measurements in the non–weight-bearing position, weight-bearing methods of STJN measurement have been developed. The use of an inclinometer to measure standing calcaneal angle and the use of a ruler to measure standing navicular drop were compared by Sell et al.[17] Both methods of measurement involved the same palpation criteria as those of the non–weight-bearing method described by Wernick and Langer.[18] Subjects, however, were instructed to actively supinate and pronate their ankle in standing until the STJN position was reached. Using the ICC, intrarater reliability for the calcaneal angle method was 0.85 for the STJN position and 0.91 for measuring the difference in calcaneal angle between STJN position and the relaxed stance position. Interrater reliabilities of 0.79 and 0.85 were reported for these two measurements. The navicular drop method exhibited intrarater reliability of 0.92 for measuring the height of the navicular with the foot in a STJN position and of 0.83 for the difference between height of the navicular at STJN position and that of the relaxed stance position, with an interrater reliability of 0.87 for the STJN position and 0.73 for the difference in measurements.[17] Therefore, for the purpose of this study, the measurement of the navicular height was chosen to quantify the position of the subtalar joint.

Studies have been performed to determine the extent of MLA support from various taping procedures. However, researchers have not yet investigated

the effects of these procedures on obtaining and maintaining the neutral position of the subtalar joint.[2,16] The purposes of this study were (1) to determine if the modified low-Dye MLA taping procedure, as described by Schulties and Draper,[16] places the subtalar joint into the neutral position and (2) to determine if the taping procedure maintained the STJN position following 10 minutes of walking.

METHODS

Subjects

A sample of convenience of 45 subjects volunteered for the study (20 men and 25 women). All volunteers signed informed consent forms prior to participation, and the rights of all subjects were protected. All subjects were interviewed to ensure that they had been free from ankle and foot injury or pathology in the past 6 months. This study was approved by the University of Central Arkansas Institutional Review Board.

Procedures

Gait Template Construction A dynamic gait template was constructed for each subject to stand on during all measurements, as described by Sell et al[17] and McPoil et al.[11] The purpose of gait template construction was to confirm that functional angles (toe-out in relation to midline) of the feet were achieved, to ensure consistency of foot position, and to encourage equal weight distribution for all measurements.

Each subject was asked to dip both feet into water-soluble paint and step out onto a 6-meter strip of butcher paper with both feet side-by-side. Each subject was instructed to walk at a normal pace to the other end of the paper, then to step off the paper into a bucket of clean water and to wash his or her feet. Immediately, the subject's name was written on the back of the butcher paper to ensure that the measurer was properly masked. This technique preserved the subject's foot position as observed during normal gait. Specifically, the middle 4 footprints were preserved for template construction. A straight line was drawn between the medial heel edges of the 2 right footprints; the same was then performed between the 2 left footprints. The distance between the 2 lines determined the base, or width, of each subject's gait. The 2 lines were then bisected by drawing a line down the measured center. After cutting along the bisection line, the 2 footprints were aligned beside each other. The result was a right and left footprint template that preserved the normal toe-out pattern of the subject's gait.

Navicular Marking As per McPoil et al[11] and Sell et al,[17] all subjects were instructed to kneel on both knees on the measurement table and hang their feet off the edge. The measurer, seated on a chair in front of the table, palpated the navicular tuberosity on the medial aspect of 1 of the subject's feet and marked the most prominent point with a dot. Only 1 foot was marked for each subject. To ensure equal distribution of the right and left feet, the marked side was alternated on each subject.

The distance between the navicular and the table surface was measured using a plastic ruler placed in a foam block (Figure 1). Both the foam block and the plastic ruler were cut by machine to ensure that the ruler maintained a perpendicular orientation to the table in all planes. The purpose of the modification was to ensure greater control of measurement and to avoid measurement error by the researcher.

Data Collection

Navicular Height: Relaxed-Stance Condition All subjects were instructed to stand on the measurement table with their backs to the measurer, on their respective gait template. Subjects placed their feet in the prints on the template, which was taped to the measurement surface, to maintain functional toe-out position of gait. All subjects were also instructed to maintain forward position and not to rotate their bodies. An initial measurement of navicular height in normal stance (relaxed position) was measured by the examiner and recorded by a monitor. The examiner did not have access to the data until after the study was performed.

Navicular Height: STJN Condition Each subject was placed in his or her respective STJN position. To accomplish this position, the talar head was palpated on both the medial and lateral sides with thumb and forefinger in the sinus tarsi just anterior and inferior to the medial and lateral malleoli of the ankle complex. Where appropriate, each subject was instructed

FIGURE 1. Measurement of the subtalar joint neutral position in weight bearing (via talus palpation and measurement of navicular height) performed with a plastic ruler imbedded in a foam block.

to roll his or her ankle out and in and was cued through palpation. The STJN position was determined by palpating the talar head until neither the medial nor the lateral aspect of the talar head was more prominent than the other. The subject was then instructed to hold the STJN position. Continuing to palpate with thumb and forefinger of the first hand, the measurer held the plastic ruler in the foam block with the other hand and read aloud the height of the navicular at STJN to be recorded by the monitor.

Any individual who exhibited a foot with a neutral or supinated subtalar joint was excluded from the study. The criterion for this exclusion was determined by the navicular drop method of STJN measurement. For the purposes of this study, only subjects who exhibited a pronated subtalar joint were accepted to ensure that correction for pronation could be made via the modified low-Dye MLA taping procedure.

The difference between STJN and the relaxed position was calculated immediately and used as a screen for inclusion into the study. If the difference was negative or if no difference existed, the subject was excluded from the study. In other words, all persons who had supinated (negative difference) or neutral (no difference) subtalar positions were excluded. If the difference between STJN and the relaxed position was a positive number, the subject had a pronated subtalar position and was included in the study.

Taping Procedure This study used a modified low-Dye MLA taping procedure designed to reduce excessive pronation that was described by Schulties and Draper.[16] To avoid bias and to ensure that the taping procedure was performed correctly and consistently, an experienced clinician with no vested interest in the study performed all taping procedures. The clinician was chosen for his experience as both a physical therapist and athletic trainer. He possessed eight years of experience in the field of athletic training, during which he became efficient in ankle and foot taping, including the standard low-Dye MLA taping procedure.

Each subject was placed in either long sitting or supine with the lower leg supported by the table. To enhance the tape adherence to the skin, adherent spray was applied to the skin of the foot before application. An initial anchor was placed around the metatarsal heads. Figure-of-eight strips of tape were then placed on the sole of the foot while the forefoot was passively everted and the first metatarsal plantar flexed with pressure applied to the metatarsal heads. The figures-of-eight were applied by attaching the tape to the dorsomedial aspect of the first metatarsal head, encircling the posterior aspect of the calcaneus medially while applying tension to the tape to avoid calcaneal eversion, pulling the tape obliquely across the plantar surface of the foot, and attaching the strip again to the anchor over the dorsomedial aspect of the first metatarsal head. As suggested by Schulties and Draper,[16] care was taken not to evert the calcaneus, which would effectively pronate the subtalar complex. Three to five figure-of-eight strips were applied to each foot, depending on the size of the foot and the area available. Each strip was applied while the forefoot was passively everted, plantar flexed, and adducted on the rearfoot. Following figure-of-eight application, lateral-to-medial strips of tape were applied to the plantar surface of the foot, beginning on the calcaneus and moving anteriorly until reaching the first cuneiform. The direction of the tape was then reversed to pull from medial to lateral in order to further evert the forefoot and plantar flex the first metatarsal, taking care not to excessively evert and plantar flex the forefoot as to cause excessive supination during weight bearing. The taping technique was completed by applying strips around the transverse plane of the foot, from the dorsomedial aspect of the first metatarsal head to the dorsolateral aspect of the fifth metatarsal head. Finally, to secure the tape that was applied to the plantar surface of the foot, strips of tape were added over the dorsum of the foot. Each subject was then instructed to return to the measuring table where navicular height measurements were again taken. No portion of the navicular tuberosity was covered by tape.

Navicular Height: Taped-Prewalking Condition Following taping, subjects were instructed to stand on their respective gait templates with their backs to the measurer. Again, navicular height was measured while the subjects were in bilateral relaxed stance. The subjects were not placed in STJN position. The navicular was repalpated but was not remarked. Height of the navicular supported by tape was determined by the measurer and recorded by the monitor.

Walking To standardize the amount of exercise that each subject performed, a monitor ensured that each subject walked exactly 10 minutes at a normal pace. A quarter-mile track, which was approximately 10 feet from the measurement and taping tables, was used for exercise. Each subject was instructed to walk with shoes on at a normal pace for 10 minutes.

Navicular Height: Taped-Postwalking Condition Immediately following exercise, subjects were measured for navicular height while the tape was still in place. All subjects were instructed, as in the previous measurements, to relax and stand normally on their respective gait templates. The navicular was repalpated but was not marked again. Navicular height measurements were taken using the plastic ruler in the foam block.

Data Analysis

Data collection resulted in 4 measurements for each subject. Table 1 outlines the design of the study and illustrates the order in which the 4 measurements were made.

Data were analyzed with a repeated measures analysis of variance (ANOVA). To determine if statistically significant differences existed among the three measures, following a statistically significant F value, the Bonferroni multiple comparisons test was performed to determine where the specific differences existed. The alpha level was set at $P < 0.05$ for the 1-way repeated measures ANOVA and at $P < 0.05$ for the Bonferroni multiple comparisons test.

Preliminary Reliability Study

Prior to studying the effect of the modified low-Dye MLA taping procedure on the STJN position, a reliability study was performed. Measurement of the STJN position using the navicular drop method of measurement, as described by Sell et al,[17] was performed on 200 volunteers. Both feet of each subject were measured, resulting in the practice of measurement of 400 feet.

Following the practice phase, 29 volunteers, both men and women from 21 to 48 years of age, were recruited. A reliability study was designed to examine intrarater and interrater reliabilities for the navicular drop technique of STJN measurement among 4 individuals with varying levels of experience in performing the measurement technique. Measurements reported here are only those of the measurer used in the current study. All volunteers signed informed consent forms prior to participation in the study.

Measurements were performed using the same instrumentation as described in the previous section. Masked measurements on both right and left lower extremities of the subjects were taken on two separate occasions. Subjects were measured in groups of 5 or 6, standing on tables with only their feet visible to the measurer. Subjects stood on gait templates to standardize stance position between trials. Both right and left feet were measured for conditions of (1) navicular height in normal stance (relaxed position) and (2) navicular height at the STJN position. The order of the subjects was then rearranged and measurements were performed a second time. Intertester reliability and intratester reliability for measuring STJN position via the navicular drop technique were established using an intraclass correlation coefficient (ICC). For the present study, however, only intrarater reliability is relevant.

RESULTS

Subjects

The screening procedure resulted in the exclusion of 2 men and 3 women. The study therefore consisted of 18 men and 22 women, ranging from 20 to 48 years of age, with a mean age of 27 years.

Reliability

Data analysis revealed that reliability was excellent for both the measurer's ability to place the subtalar joint in the neutral position and to measure the position of the navicular tuberosity and/or subtalar joint in normal stance (relaxed position). Intraclass correlation coefficients ranged from 0.94 to 0.96 for all measurements performed.

Navicular Height

The mean difference between the navicular height in the relaxed position and the STJN position was 5.55 mm, with a range of 1 to 17 mm and a standard deviation of 3.75 mm.

A 1-way repeated measures ANOVA was performed to determine if significant differences existed among the 4 measurements. Table 2 shows descriptive statistics for each of the 4 measurements. The mean navicular height was 42.9 mm for the relaxed stance, 48.5 mm for the STJN position, 50.1 mm for the taped-prewalking position, and 47.3 mm for the taped-postwalking position. The alpha level for the repeated measures ANOVA was set at 0.05. The 1-way repeated measures ANOVA demonstrated a statistically significant difference among the means ($F = 61.6$; $P = 0.00$) as shown in Table 3.

Post hoc analysis to determine where the significant differences occurred was performed using the Bonferroni multiple comparisons test. As illustrated in Table 4, the Bonferroni analysis demonstrated that a statistically significant difference ($P < 0.05$) was found between the relaxed position and all other measures. A significant difference was not found between the height of the navicular at STJN and height

TABLE 1. Design of research study.

Measure 1	Measure 2	Intervention	Measure 3	Activity	Measure 4
Navicular height (relaxed stance)	Navicular height (STJN* position)	Arch taping	Navicular height (taped-prewalking)	10 min of walking	Navicular height (taped-postwalking)

*Subtalar joint neutral.

TABLE 2. Descriptive statistics of navicular height measurements (navicular tuberosity to the floor).

Conditions*	Mean (mm)	SD (mm)	Range (mm)
Relaxed stance	42.9	9.1	21–59
STJN† position	48.5	7.8	31–66
Taped-prewalking	50.1	8.1	34–67
Taped-postwalking	47.3	9.2	28–65

* n = 40 in each group
† Subtalar joint neutral.

of the navicular supported by tape before exercise. In addition, no significant difference occurred between the STJN measurement and height of navicular after 10 minutes of walking with continued support by tape. Significant differences were found between the taped-prewalking and the taped-postwalking conditions.

DISCUSSION

It is critical to note that a significant difference existed between the relaxed position of the foot and the other three measures. This demonstrates that a difference between the typical posture of the subject's foot and the subtalar neutral position did indeed exist.

Since no difference was found between navicular height in the STJN position and the taped-prewalking conditions, it may be concluded that the modified low-Dye MLA taping procedure placed the subtalar joint into the neutral position. The taping procedure was found to maintain the neutral position of the subtalar joint through 10 minutes of walking because no significant differences existed between navicular heights in the STJN position and taped-postwalking condition. Consistent with the literature, the results showed significant differences between the taped-prewalking and taped-postwalking conditions.[2,5,6,12,18] By the end of 10 minutes of walking, the height of the MLA had fallen significantly from the initial taped position. As illustrated in Figure 2, the mean height of the navicular supported by tape (50.1 mm) was almost 3 mm higher than the mean height of the taped-postwalking navicular (47.3 mm). Perhaps this was due to a loss in tensile strength, slippage of the tape, skin perspiration, or skin movement.

Initially, these findings seem contradictory. However, as illustrated in Table 2, the mean for the taped-prewalking condition is actually higher than that of STJN position (though not significantly), while the mean for taped-postwalking condition is lower than that of the STJN position. These observations account for the significant difference between the taped-prewalking and taped-postwalking conditions, without significant differences between the STJN position and the taped-prewalking and the taped-postwalking conditions.

These findings may indicate that the modified MLA taping procedure overcorrected for pronation, placing the navicular into a position slightly higher than the STJN measurement. This overcorrection may have allowed some loss of support by the tape, yet still maintained the position of the navicular within a range not statistically different than STJN through 10 minutes of walking.

Clinical Application

The low-Dye MLA taping procedure has been used to determine the necessity of orthotics. Patients whose symptoms are reduced or relieved after application may warrant an orthotic intervention. Raising the arch with tape alleviates pain; orthotics provide similar relief. The low-Dye MLA taping procedure may be useful for static positioning of the subtalar joint while fabricating orthotics, thus saving time and energy for both the clinician and the patient.

The literature demonstrates that taping is not feasible for long-term treatment of lower extremity pa-

TABLE 3. One-way ANOVA results for comparison among navicular height for 4 tested conditions.

Source	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	P Value	Power
Treatment	1160.9	3	386.9	61.6	0.00	1.00
Error	734.1	117	6.2	—	—	—

TABLE 4. Summary of statistically significant differences ($P < 0.05$) for navicular height among the 4 tested conditions.

Conditions	Count	Mean (mm)	Different From
Relaxed stance	40	42.9	STJN,* taped-prewalking, taped-postwalking
STJN* position	40	48.5	Relaxed stance
Taped-prewalking	40	50.1	Taped-postwalking
Taped-postwalking	40	47.3	Taped-prewalking

* Subtalar joint neutral.

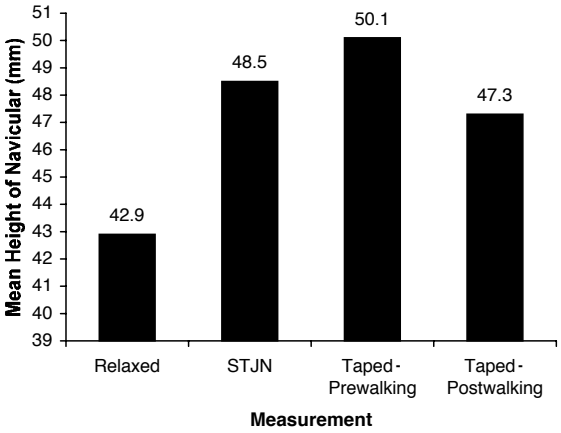

FIGURE 2. Mean height of the navicular tuberosity for relaxed stance, subtalar joint neutral (STJN) position, taped-prewalking, and taped-postwalking (n = 40 in each group).

thologies.[2,5,6,12,19] Though the modified low-Dye MLA taping may not maintain the neutral foot, as Ator et al[2] have reported, the procedure could possibly alleviate some of the pronation even after considerable exercise. For athletes in training or competition, repeated applications of the taping procedure may provide adequate relief.[2]

The measurer in this study established an intrarater reliability ICC of 0.96 and an ICC of 0.94 for right and left measurements, respectively, for measuring STJN position using the navicular drop technique. This high degree of intrarater reliability could possibly be attributed to the examiner's performance of 400 practice measurements prior to the reliability study. This contributed to the internal validity of the study by reducing possible measurement error. The navicular drop measurement procedure contributed to the internal validity and construct validity because it is the most reliable and clinically applicable tool for analyzing the joint position.[4,17] The measurement is based on anatomical and biomechanical theory and is applicable in the clinic because of the efficient and functional weight-bearing measurement.

The physical therapist and athletic trainer who performed the taping had more than eight years of experience using the standard MLA procedure and was, therefore, considered reliable. Using only one person for taping provided more control and contributed to the internal validity of the study. All measurements of each subject were performed on the same day with the same mark on the navicular tuberosity, ensuring more accurate measurements. The measurer was masked to previous measurements to provide more control of the study. Finally, gait templates controlled changes in stance of the subjects and provided reliability of foot placement.

Suggestions for future study are as follows: (1) measure the subtalar position following varying levels of exercise to provide more information about the modified low-Dye MLA taping procedure's ability to extend support for various conditions; (2) determine if it is the MLA taping procedure or the therapists' taping skills that overcorrect pronation to the point of supination; and (3) ascertain if the taping procedure would be useful for static positioning of the subtalar joint while fabricating orthotics.

CONCLUSION

A significant difference did exist between the relaxed position and all three other measures. In addition, no significant differences were found between the height of the navicular at subtalar neutral and the height of the navicular supported by tape both before and after 10 minutes of walking. However, significant differences occurred between the height of the navicular supported by tape (before walking) and the height of the navicular following walking (with continued support by tape). In conclusion, the modified low-Dye MLA taping procedure may be an effective tool for placement of the subtalar joint into the neutral position. The procedure may also be effective for maintaining the STJN position through light exercise up to 10 minutes. However, the study did not investigate whether or not the tape will continue to maintain the neutral position of the subtalar joint through more vigorous or longer periods of exercise.

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