USE OF ANTPRONATION TAPING TO DETERMINE FOOT ORTHOSES PRESCRIPTION: A CASE SERIES

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In order to determine if the use of antipronation taping could be used to direct foot orthoses prescription, seven high school athletes with lower extremity or foot pain caused by overuse stress were taped for 3 days during practice sessions. A visual pain scale and the Foot and Ankle Ability Measure sports subscale were used to monitor pain and function improvement caused by taping. If the taping was effective, foot orthotics were fabricated and posted according to the change in foot posture created by the tape. After wearing the foot orthotics for 4 weeks, all athletes reported a substantial short-term (4-week) reduction in pain and an increase in function. The results of this case series indicate that changes in foot posture created by taping can be used to guide foot orthosis prescription.

Keywords: antipronation taping, foot orthoses, pain, function
INTRODUCTION

Foot orthoses often are prescribed for the management of exercise-related overuse injuries that can occur in the lower extremity and foot. Wilder and Sethi (2004) have stated that approximately 50% of all sports injuries are caused by overuse from repetitive microtrauma that results in local tissue damage. James et al. (1978) were one of the first researchers to describe the use of foot orthoses to control abnormal foot pronation, which was thought to decrease overuse stress on lower limb soft-tissue structures in running injuries such as patellofemoral joint pain, shin splints, Achilles tendinopathy, heel pain, and lower-limb stress fractures. Several other authors also have anecdotally reported on the successful use of foot orthoses to control foot pronation and minimize overuse stress on soft tissues as well as decrease associated symptoms (Schuster 1972; Subotnick 1975). Previous retrospective studies have shown that excessive dynamic foot pronation is present in subjects with a history of lower-leg pain (Messier and Pittala 1988; Viitasalo and Kvist 1983). More recently, Willems et al. (2006) reported that subjects with exercise-related lower-leg pain had a significant increase in foot pronation while running barefoot.

While foot orthoses are a common intervention used in the management of exercise-related overuse injuries for the purpose of modulating the amount of foot pronation, theories for determining the optimal orthosis prescription are limited. The most widely used approach for the prescription and fabrication of foot orthoses would appear to be the paradigm proposed by Root et al. (1971). Landorf et al. (2001) surveyed podiatrists in Australia and New Zealand and reported that the majority of these practitioners still utilize the Root et al. paradigm when prescribing orthotics. In addition the Root et al. paradigm is presented in numerous textbooks utilized by podiatry, physical therapy, and athletic training education programs throughout the United States (Michaud 1993; Valmassy 1996).

The paradigm proposed by Root et al. (1977) was based on the premise that a “typical” foot posture or alignment is required for normal function. The clinician assesses the typical foot posture after placing the subtalar joint in a neutral position, using palpation, while the athlete is non-weight bearing. They justified the use of this foot placement by stating that the neutral position of the subtalar joint occurred at approximately halfway through stance phase while walking. Any deviations from typical foot posture, termed intrinsic deformities, would cause abnormal foot motion and in most cases lead to excessive foot pronation. These intrinsic deformities then were corrected with foot orthoses that incorporate wedges, also termed posts, that were positioned in the rear, fore, or both parts of the foot orthosis. The purpose of the posts, in conjunction with the foot orthoses, was to control excessive foot pronation.

McPoil and Hunt (1995) were the first to identify several serious concerns regarding the underlying suppositions of the Root et al. paradigm. These
major concerns include the following (1) the lack of evidence to support the notion that subtalar joint neutral position occurs during midstance in walking (McPoil and Cornwall 1994; McPoil and Cornwall 1996a; Pierrynowski and Smith 1996), (2) the poor levels of reliability for the physical measurements required to assess foot structure in order to determine proper foot orthosis prescription (Evans et al. 2003; Van Gheluwe et al. 2002), and (3) little evidence to support the concept that intrinsic deformities cause increased foot pronation (Cornwall and McPoil 2004; McPoil and Cornwall 1996b). In addition, the Root et al. paradigm required that the assessment of foot alignment be performed while the subject was non-weight bearing. As a result, the clinician could presume only that the intrinsic deformity they observed and the proposed increase in foot pronation that would occur as a result of the deformity was actually a factor in the development of the athlete’s overuse injury. Thus, the clinician could prescribe foot orthoses with a specific amount of posting, determined by the degree of the intrinsic deformity they had measured, but not know if the foot orthoses would be of benefit in reducing the athlete’s pain and symptoms. In light of these problems associated with the Root et al. paradigm as well as the fact that foot orthoses represent a significant financial investment, the development of a practical and functional-based scheme to determine the appropriate orthosis prescription would appear warranted.

Vicenzino (2004) described what he termed the Treatment Direction Test (TDT), which utilizes antipronation taping of the foot to determine if controlling excessive foot pronation would result in a reduction of an athlete’s pain and discomfort that were associated with his or her sport or physical activity. The central feature of the TDT is the combined use of physical activity that provokes pain and the use of antipronation taping techniques applied by the clinician. In this model, the subject first performs the physical activities that are known to create pain. The clinician then applies the antipronation tape and the patient is asked to repeat the same physical activities. The TDT is considered positive if there is a decrease in pain as a result of antipronation taping and it is assumed that the subject would benefit from an orthosis. If there is no difference in pain when the physical activities are repeated after the application of the antipronation tape, the result of the TDT is negative and an orthosis would not be recommended. Several previously published case studies (Hadley et al. 1999; Smith et al. 2004) have reported on the success of using the TDT to determine if foot orthoses should be considered as a component of the management program for athletes with lower extremity or foot overuse injuries. Furthermore, Vicenzino et al. (2005) also have reported that an antipronation tape was effective in reducing foot pronation during dynamic tasks such as walking and jogging.

Although the TDT has been shown to be a successful and practical approach to guide the practitioner in determining if a foot orthosis should be prescribed, a weakness of the TDT is that even if a positive effect is reported
by the athlete, the TDT does not provide the practitioner with the information necessary to determine the degree of posting, or correction, that should be added to the foot orthoses. In other words, while the antipronation taping of the foot to modulate foot pronation may have led to a reduction in the athlete’s pain and symptoms, the TDT fails to provide the practitioner with information regarding the amount of change in foot posture that was created by the tape. Thus, even though the practitioner may know that controlling foot pronation can be beneficial for the athlete, the degree of posting that should be added to the foot orthoses to replicate the effect of the tape on foot posture is unknown.

Thus, the purpose of this case study series is twofold. First, can a positive TDT, as a result of applying antipronation taping to the foot, be used to indicate if a foot orthosis should be prescribed? Second, if the TDT produces a positive result, can the change in foot posture created by the antipronation taping of the foot be used to guide the prescription of the foot orthosis?

**METHODS**

**Subjects**

Seven high school athletes with a mean age of 16 years (range 15 to 18 years) and with an overuse-related lower extremity or foot pain for at least 2 weeks were eligible to participate in this study. All participants were initially observed during walking and standing by one of the investigators (TL) who hypothesized if controlling the athlete’s foot pronation might be of benefit in managing his or her overuse injury. In addition, the participant had to have at least 5 remaining weeks of their sport season so that they could complete the study while still participating in the sport that caused their specific overuse injury. If an athlete met the above criteria, the study protocol was explained to both the athlete and at least one parent or guardian. Both the athlete and the parent or guardian had to provide their informed consent in order for the athlete to participate in the study. Based on the above criteria, seven athletes consented to participate in the case series. The seven athletes, six females and one male, participated in the following sports; American football, cross-country, basketball, and volleyball. The overuse injuries that led to the athlete’s complaint of pain and other symptoms included the following: iliotibial band friction syndrome, anterior knee pain, medial longitudinal arch pain, and medial tibial stress syndrome. The duration of the symptoms for the seven athletes ranged from 2.5 to 5 weeks.

**Taping Methods**

The two antipronation taping techniques applied to each athlete in the study were the augmented low-dye and the reverse six taping procedures. For
each taping procedure, the athlete sat with his or her feet off the end of a table and placed in a moderately inverted position. The augmented low-dye taping technique was identical to the procedure described by Vicenzino (2004) and was applied using 3.81 cm wide Zonas athletic tape (Johnson & Johnson, NJ). Prior to applying the reverse six tape strips, a foam pretaping material (Cramer Co., KS) was applied to the foot and lower leg of the athlete to prevent possible skin irritation. The reverse six strips were applied using three pieces of 5.08 cm wide Elastikon tape (Johnson & Johnson, NJ). For the first and second strips, the elastic tape was started on the dorsal aspect of the foot and applied over the lateral aspect of the foot while removing only half of the stretch of the tape. As the strip was pulled under the medial arch region of the foot, all of the stretch was removed from the elastic tape to lift up the medial longitudinal arch region of the foot. Once the elastic tape had passed over of the medial arch of the foot, the tape was placed just above the lateral malleolus and passed behind the lower leg to end just above the medial malleolus, with only half of the tape stretch removed. The third and final strip of elastic tape was placed on the athlete in the same manner as the first and second strips, except after passing over the medial malleolus, the tape was wrapped around the lower leg another time to prevent slippage of the first two strips of elastic tape. The same investigator (KM) applied all taping procedures on all athletes.

**Outcome Measures**

To assess the effectiveness of the taping procedures and foot orthoses in reducing pain and improving function during athletic activity, two outcome measures were used. To assess perceived pain, subjects completed a visual analog scale (VAS) scored from 0 (no pain) to 15 (worst possible pain), depending on the location marked by the subject on a 15 centimeter (150 millimeter) line. This scale has been established as a reliable and valid instrument to measure acute and chronic pain (Bijur, Silver, and Gallagher 2001; Downie, Leatham, and Rhind 1978). To assess improvement in function while the athlete participated in their specific sport, the Foot and Ankle Ability Measure (FAAM) was utilized (Martin et al. 2005). Martin and Irrgang (2007) reported that the FAAM met all four criteria required to be an effective outcome measurement tool including construct validity, content validity, reliability, and responsiveness. While the FAAM has both an activities-of-daily-living subscale and a sports subscale, only the sports subscale was used in this study. The FAAM sports subscale includes eight items that are scored by the athlete from 4 to 0, with a score of 4 indicating no difficulty with the functional task and 0 indicating that the athlete is unable to perform the task. Thus, the greater the FAAM score, the higher the level of function. Martin et al. (2005) have noted that
at least a 12.7 point change on the sports subscale is necessary to be considered a clinically significant improvement in function. The same investigator (KM) administered the VAS and the FAAM to all athletes.

**Procedures**

For each athlete in the study, a dynamic angle and base template, as described by McPoil et al. (1988) was fabricated from butcher paper. The use of the dynamic and base template ensured that the same distance between both feet (base) as well as the same amount of toeing-in or toeing-out (angle) would be standardized for all foot measurements. Previous researchers have reported that variations in foot placement can affect the reliability of standing foot posture measurements (McPoil et al. 1988). Once the angle and base template was completed, a longitudinal axis was drawn from the middle of the second digit to the center of the heel for both feet (see Figure 1). The total foot length then was measured from the end of the hallux to the back of the heel along the longitudinal axis. A mark then was placed at 50% of the total foot length and a line was drawn perpendicular to the first longitudinal axis. This line, representing 50% of the total foot length, was used for positioning the digital gauge to measure the dorsal arch height of each foot (see Figure 1). Prior to initiating this case series, the within-day and between-day reliability of the dorsal arch height measured using the digital gauge was assessed on 10 healthy subjects. The 10 subjects were placed on their angle and base template with line drawn perpendicular to the longitudinal axis at 50% of the total foot length.
template and the dorsal arch height was measured twice, at least one hour apart, on day one and then returned one week later to have their dorsal arch height reassessed twice a second time. The intraclass correlation coefficients (type 2, 1) based on a single dorsal arch height measurement were .97, .98, and .99 for within-day 1, within-day 2, and between days, respectively.

On the first day, the athlete initially was asked to complete the VAS and the FAAM. The athlete then was asked to stand on his or her template so that the dorsum of the foot could be marked using a water-soluble pen aligned with the 50% foot length line on the template. Next, the dorsal arch height (DAH-Pre) was measured using a digital height gauge from the supporting surface to the top of the dorsum of the foot while the athlete stood with his or her feet in a relaxed posture (see Figure 2A). The athlete then had the augmented low-dye and the reverse six taping procedures applied to both feet prior to practice for 3 consecutive days. At the end of practice on each of the 3 days, the same investigator (KM) asked the athlete if he or she believed that the taping procedures had reduced the pain and increased the level of function during practice.

Figure 2A. Dorsal arch height measured while standing barefoot using a digital height gauge.
At the end of the third day of practice, if the athlete still believed that
the taping procedures were reducing his or her pain and improving his or
her functional levels, the dorsal arch height was reassessed after the prac-
tice session for the fitting of foot orthoses. The reassessment of the dorsal
arch height was done while taped after completing the practice session to
account for any possible stretching of the tape as a result of sports activi-
ties during practice. Prior to reassessing the dorsal arch height, the athlete
was asked to complete the VAS and FAAM for a second time. To reas-
sess the dorsal arch height while taped, the athlete again was asked to
stand on his or her angle and base template while taped and a pen mark
was placed on the top of the tape aligned with the 50% foot length line on
the template. The dorsal arch height was measured from the supporting
surface to the top of the tape on the dorsum of the foot (see Figure 2B).
Next, the tape was removed and the thickness of the tape at the 50%
length mark was measured in cm. The tape thickness then was subtracted
from the dorsal arch height that was measured while the athlete was taped

Figure 2B. Dorsal arch height measured with antipronation taping
applied using digital height gauge.
Antipronation Taping and Foot Orthoses

The amount of posting or wedging applied to the foot orthotic was based on the difference between DAH-Post minus DAH-Pre. All seven athletes, who initially consented to participate in this case series, indicated that the tape was effective in reducing their pain and symptoms and continued to participate in the next phase of case series.

All seven athletes were fitted with an identically shaped prefabricated foot orthoses (Vasyli Full Length Orthotic, D-Med, Highland Park, IL) that were constructed using three different material densities: red (hardest), blue (medium), and green (softest). All athletes first were fitted with the blue density and asked to walk over a tile floor approximately 100 meters in length. If the athlete reported that the orthotic felt too hard, he or she was given a green density device and if he or she reported that the orthosis was not firm enough, the athlete was given a red density device. Once the athlete felt comfortable walking over 200 meters with the foot orthoses, the posting was added to the medial side of the orthoses in both the front and rear based on the change in dorsal arch height between DAH-Post and DAH-Pre. For example, if the tape created a 0.2 cm change in dorsal arch height, the orthosis was posted medially in the front and rear with 0.2 cm self-adhesive wedges (D-Med, Highland Park, IL). If the athlete had bilateral pain and symptoms, posting was applied to each orthosis. If the symptoms were unilateral, then the posting was applied only to the symptomatic side.

RESULTS

Table 1 lists the DAH-Pre and the DAH-Post measurements as well as the density and amount of posting applied to the foot orthoses for each athlete. Figure 3A illustrates the change in VAS scores for each athlete between pretaping and after the third day of taping, after wearing the foot orthoses for 2 weeks, and after wearing the foot orthoses for 4 weeks. Figure 3B illustrates change in the FAAM sports subscale scores for each athlete between pretaping and after the third day of taping, after wearing the foot orthoses for 2 weeks, and after wearing the foot orthoses for 4 weeks.

The maximum amount of dorsal arch height change as a result of taping ranged from 0.10 to 0.29 cm for the left foot and from 0.10 to 0.30 cm for the right foot. Thus, the maximum amount of posting used for any foot orthoses in this case study series was 0.30 cm on both the rear and fore part of the medial side of the orthotic device.

The percent change in VAS scores after 3 days of taping in comparison with pretaping ranged from 23% to 91%, indicating that the use of tape reduced pain levels for all athletes. After wearing foot orthoses for 4 weeks, the VAS scores in comparison to pretaping ranged from...
These results indicate that the foot orthoses, with posting based on the change in foot posture created by the taping, not only maintained but caused a further reduction in short-term (4 week) pain levels for all athletes.

The change in FAAM score after 3 days of taping in comparison with pretaping ranged from 2 to 11 points. After wearing the foot orthoses for...
4 weeks, the change in FAAM scores in comparison with pretaping ranged from 5 to 19. While all athletes reported an increase in function based on their improvement in FAAM scores, only four of the seven athletes achieved a clinically significant short-term (4 week) improvement in their level of sport function (>12.7) as defined by Martin et al. (2005).

**DISCUSSION**

A key question for any health care provider when managing an athlete who has an overuse injury is whether foot orthoses should be included in the plan of care. If foot orthoses are to be considered a component of the management program, the clinician is faced with the issue of how much posting, or correction, should be incorporated into the design of the foot orthoses. Another concern for the clinician is being confident in the benefit of prescribing foot orthoses for the athlete in order to justify the monetary costs of the foot orthoses. In light of these issues, the decision to prescribe foot orthoses should be determined on a functional-based assessment scheme that has confirmed a reduction in pain and associated symptoms, as a result of controlling foot pronation, while the athlete performs the provoking sport activities. The TDT described by Vicenzino (2004) provides such a model, allowing the clinician to functionally assess the change in the athlete’s pain and symptoms by controlling foot

![Figure 3B. Change in the FAAM sports subscale scores for each athlete between pretaping and after the third day of taping (Day 3), after wearing the foot orthoses for 2 weeks (2 Wk), and after wearing the foot orthoses for 4 weeks (4 Wk).](image-url)
pronation through the use of antipronation taping procedures. The purpose of this case study series was to determine if a positive TDT, as result of using antipronation taping, could accomplish the following: (1) successfully predict if foot orthoses would be a beneficial component of the management program and (2) direct the prescription of the foot orthoses based on the change in foot posture created by the taping.

The seven athletes who participated in this case study series had lower extremity and foot pain and associated symptoms as a result of overuse stress. For all seven athletes, a positive TDT resulted from the use of the antipronation taping. The athletes reported a 23% to 91% reduction in pain, based on the VAS, after participating in 3 days of practicing their specific sport while using the antipronation tape. In addition, a 2- to 11-point improvement in FAAM sports subscale scores also were observed during the three practice sessions. The antipronation taping also resulted in a change in each athlete’s relaxed standing foot posture after completing the third 2-hour practice session while taped. As a result, each of the seven athletes were fitted with prefabricated foot orthoses that were posted, based on the change in his or her relaxed standing foot posture that was created as a result of the antipronation taping.

Over the course of the 4-week period that the athletes were monitored after being fitted with foot orthoses, all seven reported a continued reduction in pain as well as an increase in function. Following 2 weeks of foot orthoses use, the athletes reported a 65% to 100% reduction in pain, based on the VAS, as well as a 4- to 19- point improvement in FAAM sports subscale scores. After wearing the foot orthoses for 4 weeks, the athletes reported a 78% to 100% reduction in pain, based on the VAS, as well as a 5- to 19- point improvement in FAAM sports subscale scores. Based on the change in FAAM subscale scores at the end of 4 weeks of wear, four of the seven athletes reported a 13-point or higher increase in the FAAM score, indicating that they had achieved a clinically significant improvement in their level of function. It is also interesting to note that none of the athletes who participated in this study required more that 0.30 cm of medial posting to the rear and fore part of the orthoses to have improvements in both pain and function as they continued his or her sport activity. Based on these findings from the current case series, the use of the TDT would appear to be effective in determining if orthoses should be considered as part of the management program and direct the prescription of foot orthoses.

A significant limitation in generalizing the results of this case series is the small number of participants who took part in the study. Other limitations include a limited number of team and individual sport activities represented, a disproportionate number of females in comparison with
male athletes who participated in the study, and the unknown effect of tape stretching. While the amount is unknown, it is assumed that some stretching of the tape occurred during practice sessions. If indeed stretching of the tape did occur, a greater degree of wedging might have increased the number of athletes achieving a clinically significant improvement on the FAAM sports subscale.

While the results of this case series are preliminary and require further validation using clinical trials with a larger cohort of participants representing a greater number of sport activities, the findings of this case series are relevant to those health care professionals who manage overuse injuries in athletes. The use of the function-based scheme, described in this case series, to determine the appropriate orthosis prescription allows the clinician not only to determine which athletes will be helped by using foot orthoses but also to understand the degree of change in foot posture required to maintain the reduction in pain and symptoms as the athlete continues his or her sport activity. Thus, only those athletes who would benefit from using foot orthoses to control foot pronation are identified, which can lead to the development of a more efficient and cost-effective management program.

CONCLUSIONS

The findings of this case study series would suggest that the TDT as described by Vicenzino (2004) can not only successfully predict if foot orthoses would be a beneficial component of the management program but also can guide the prescription for foot orthoses. Seven high school athletes with a variety of lower extremity and foot overuse injuries who were fitted with foot orthoses that were posted based on the change in foot posture created by antipronation taping reported a short-term (4-week) reduction in pain as well as an increase in functional activities associated with his or her specific sport.

REFERENCES


