An investigation of the anti-pronation effect of two taping methods after application and exercise

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Abstract

This study investigated the effect of two anti-pronation taping techniques on vertical navicular height, an indicator of foot pronation, after its application and 20 min of exercise. The taping techniques were: the low dye (LD) and low dye with the addition of calcaneal slings and reverse sixes (LDCR). A repeated measures study was used. It found that LDCR was superior to LD and control immediately after application and exercise. LD was better than control immediately after application but not after exercise. These findings provide practical directions to clinicians regularly using anti-pronation taping techniques.

Keywords: Pronation; Tape; Biomechanics; Foot; Lower limb; Physical Therapy

1. Introduction

Overuse injuries of the lower limb constitute a significant problem in terms of their prevalence and interference to athletic activity, such as jogging, aerobics and cycling [1]. Many of these injuries are associated with abnormal lower limb biomechanics such as excessive or prolonged foot pronation during stance phase of gait [1–4].

The challenge confronting the clinician who is managing a patient with an overuse lower limb condition is whether a relationship exists between the patient’s condition and any observed abnormal pronation. Rigid adhesive sports tape is often used to test this relationship [2,5,6]. A concurrent reduction or abolition of symptoms associated with the tape induced reduction of pronation confirms the link between pain and abnormal pronation. It is also a strong clinical indicator for biomechanical interventions such as orthotic and exercise therapy [2,5,6].

Most overuse conditions manifest themselves during weight bearing activities such as standing, walking, jogging or running for a period of time. Therefore, the efficacy of any taping technique can only be assessed if it is able to prevent abnormal pronation for this period of time. Ator et al. [7] demonstrated that although two commonly used taping methods (Low Dye (LD) and Double-X (DX)) were able to reduce pronation immediately after their application, this effect was not present after 10 min of jogging. The loss of effectiveness with tape following activity is one criticism often levelled at its use [8]. One possible reason for the loss of effectiveness of LD and DX after exercise could be the poor leverage exerted by tape applied solely to the foot. It is our experience that adding calcaneal slings and reverse sixes to the LD (LDCR) produces a greater and longer lasting anti-pronation effect. The extension of tape up the limb has been previously suggested to increase support in cases requiring it [5].

In the closed kinetic chain, pronation is a triplanar motion which involves as well as other movements; plantarflexion and adduction of the talus, unlocking of the midtarsal joint, forefoot abduction and a reduction in the medial longitudinal arch and vertical navicular height (VNH) [1,9]. An excessive amount of these motions occur when abnormal pronation is present [10]. The VNH is a reliable and valid indicator of pronation and has been previously used in research [7].

The purpose of this study was to investigate the difference between LD and LDCR on VNH immediately following application and after exercise.
2. Methods

2.1. Subjects

Seventeen female subjects aged between 16 and 21 years old (18.5 ± 1.3 years) were recruited from the University of Queensland student population. Volunteers were recruited into the study on the basis of an observable increased pronation in standing and if they also exhibited at least a 1.5 cm improvement in VNH when their foot was moved from a relaxed stance position to a neutral subtalar joint position as determined by the palpation method. They were excluded if they had experienced any form of prophylactic sports taping to the foot or if they had any current injuries to the lower limbs which required a reduction in activity level and/or medical attention. A tape allergy test was conducted on all subjects to ensure that no subjects would be adversely affected by the tape. All subjects regularly participated in some form of athletic and/or fitness activity. Thus they were all capable of performing the controlled structured exercise program without risk of injury. After being informed of the study's requirements all subjects signed a consent form that was approved by the University of Queensland medical research ethics committee.

2.2. Apparatus

A Vernier Caliper (Mitutoyo, Japan) was used to measure the VNH from the floor (Fig. 1). This instrument is calibrated to 0.02 mm and is constructed in such a manner that the VNH could be measured perpendicular to the floor.

2.3. Taping methods

Leuko Premium Sportstape (38 mm, Biersdorf Pty Ltd, Australia) which is a rigid sports tape with a zinc-oxide adhesive was used. The tape was applied while the subject was positioned in supine with the leg suspended over the end of the table. The important technical aspect of applying these techniques is the initial positioning and then maintenance of the foot in a slightly supinated position at the subtalar and midtarsal joints while the talocrural joint is held in neutral. A sports physiotherapist experienced in the application of these taping methods applied all tape ensuring that the appropriate position was maintained during their application as would be the case in a clinical situation.

2.3.1. Application of the LD technique

(i) A spur was applied by initially placing the tape medially over the first metatarsal just proximal to the first metatarsophalangeal joint and then laying the tape along the medial side of the foot. Some longitudinal traction was then applied to the tape in order to oppose any forefoot abduction, often a component of abnormal pronation (Fig. 2). The tape is then placed on the lateral side of the foot extending to the fifth metatarsophalangeal joint.

(ii) A series of mini-stirrups was then applied (Fig. 3). These started over the spur on the lateral side of the foot and extended along the lateral side of the foot to the fifth metatarsophalangeal joint.
foot, perpendicular to it, were then placed across the sole of the foot and anchored onto the spur medially. Some longitudinal traction was applied to these so as to oppose pronation. The next mini-stirrup was applied so that it covered the previous one by about half its width. This continued in a proximal direction until the calcaneum was covered.

(iii) A spur was then applied as in (i) to lock off all mini-stirrups. The completed low dye is shown in Fig. 4.

2.3.2. Application of the LDCR technique
In addition to the LD technique described above the LDCR technique involved:

(i) the application of an anchor strip circumferentially applied at one third up the leg;

(ii) The calcaneal sling originated from the anterior centre part of this anchor. It coursed distally in an oblique orientation towards the medial malleolus, passed under the midfoot and then obliquely over the lateral and posterior calcaneum (Fig. 5). The tape then ran proximally in a longitudinal manner until it inserted on its origin at the anchor tape (Fig. 5). Two of these were applied;

(iii) three reverse sixes were used. They began at the medial malleolus passed over the dorsum of the ankle, then around the midfoot in a lateral to medial direction before crossing over their origin and continuing up to the anchor strip (Fig. 6). A complete LDCR is shown in Fig. 7.

2.4. Protocol
This study used a randomised repeated measures (taping method x measurement time x subject), double blind, research design. Subjects were randomly assigned to a taping method such that each subject experienced
both LDCR and LD over the course of the experiment. The left foot was used as a control and was measured at all measurement times.

In order to standardise the foot position between each measurement time, a template of each subject's foot was made at the first session. The subject's feet were positioned parallel to each other with 20 cm between the left and right calcaneal bisectors. The posterior aspects of the heels were also aligned. The outline of the subject's feet was marked onto the A3 sized paper (the template) on which they were standing (Fig. 1). Also drawn onto the template was the placement position for the vernier callipers and the subject's name and number.

At each experimental session a standardised protocol was followed. On arrival, subjects right foot and lower leg was washed with soap and warm water to remove oil and dirt so as to allow for optimum adhesion of the sports tape. Any hair in the region to be taped was removed. The navicular tuberosity was identified by palpation and marked with an indelible ink pen. This mark remained visible when tape was placed over it, allowing for the mark to be transferred to subsequent layers of superimposed tape.

VNHs were then measured prior to tape being applied. The subject stood on her template on a raised platform (Fig. 1) and looked straight ahead at a designated point on the wall. The investigator who was aligning the vernier callipers to the navicular tuberosity was blind to the measurement scale of the callipers (Fig. 1). Another investigator recorded the observed measurement from the scale onto specially constructed recording sheets. The VNH was measured twice. The subjects then had either the LD or LDCR technique applied on a randomly assigned basis. A piece of tubigrip was applied to the leg extending down to just above the level of the navicular tuberosity, thus ensuring the investigator measuring the VNH could not tell which technique was applied (Fig. 1). The VNH was remeasured and the subjects engaged in the standardised exercise activity. This involved jogging around a 28 m figure of eight track. This jogging was conducted on a uniform surface within the Department of Physiotherapy, University of Queensland. Two investigators checked that each subject completed the same number of circuits between the two 10 min exercise periods and between the 2 days. The VNH measurements were repeated after the two 10 min exercise periods. On completion of the session blunt nosed scissors were used to remove the tape. Investigators examined the skin for any signs of adverse skin reaction. Subjects attended two days later in which the only protocol change was the application of the alternative taping method to that applied on the first day.

### 2.5. Data analysis

The two measures of VNH taken for each taping method at each measurement time were used in the intraclass correlation coefficient (ICC) analysis for intrarater reliability. The root mean square error (RMSE) was also calculated in order to quantify the error involved with the measure of VNH.

An average of both VNH measures was used in the analyses. All post-application data was expressed as a percentage of the pre-application VNH measurement (%VNH). This was the dependent variable. The independent variables were taping method and measurement time, each of which had three levels. The three levels of taping methods were LDCR, LD and control. The three levels of measurement time were 0 min (immediately post application), after 10 min of exercise and after 20 min of exercise. The 2-way repeated measures study design was tested using procedure MANOVA on SPSS 4.0 for the Macintosh computer (Apple). Significant effects were further analysed with a Tukey-HSD test ($P < 0.05$).

### 3. Results

The VNH measurement demonstrated good intrarater reliability with an ICC of 0.98 and a RMSE of 2.7% (0.9 mm).
The mean ± standard error (S.E.) for LDCR, LD and control at the three measurement times are presented in Fig. 8. The omnibus 2-way repeated measures ANOVA revealed significant main effects for the taping method, measurement time and their interaction (P < 0.0001).

3.1. Comparison of taping techniques at each measurement time

Immediately after their application, LDCR (118.8) produced a significantly greater %VNH than did LD (108.3). Both of these techniques were superior to the control (98.7). At the 10 and 20 min measurement times the %VNH was significantly greater for LDCR (108.6 and 105.7, respectively) than for LD (94.2 and 91.3) and the control (95.4 and 95.9). There was no significant difference between LD and control throughout the exercise period.

3.2. Effect of exercise on each taping method

The %VNH had significantly reduced with the LDCR technique from 118.8 to 105.7 over the 20 min exercise period. This was a gradual reduction as there was no significant difference after each of the 10 min exercise periods.

The LD technique demonstrated a significant reduction in %VNH from 108.3 to 94.2 over the first 10 min exercise period. There was no further significant reduction in %VNH over the second exercise period.

In the control condition the biggest reduction in %VNH occurred over the first 10 min exercise period with a reduction from 98.7 to 95.4. No significant changes occurred in the second exercise period.

4. Discussion

The findings of this study substantiate the clinical assertion that augmenting the LD taping method by adding techniques which extend up the lower leg (calcaneal slings and reverse sixes) provide a better control of pronation immediately after application and after a period of exercise. The methodology and the good intrarater reliability and low error inherent in the measurement of VNH strengthens the confidence with which the results of this study are interpreted.

LDCR performed better than LD and control at all measurement times even though its effect had significantly diminished after 20 min of exercise. The LD method significantly increased the VNH immediately following its application but this effect was significantly diminished after 10 min of exercise. The findings with regard to the LD are similar to those reported by Ator et al. (1991). These findings indicate that the LDCR method is the method of choice in the patient who exhibits abnormal pronation and pain on activity such as jogging for periods of 10 or 20 min. The LD method would be sufficient in patients whose pain is exacerbated only on weightbearing.

The good anti-pronation effect conferred by LDCR after 20 min of exercise would implicate it as a suitable prophylactic strategy in individuals who have been identified as having a high risk of developing a lower limb overuse injury [11], especially if participating in high risk sports such as jogging, aerobics and cycling. Although this requires further investigation

5. Conclusion

The addition to the LD of techniques which extend up the distal leg provides for better anti-pronation control than does the LD by itself. This is the case for immediately post-application and following 20 min of exercise. The efficacy of the LDCR in providing this support after a period of exercise validates its use in testing the relationship between symptoms which present with exercise and abnormal pronation.

References