THE ACUTE EFFECTS OF TAPING ON PROPRIOCEPTION IN THE ANKLE WITH PREVIOUS INVERSION SPRAIN

Mr. Pat McLaughlin B. App. Sc (Phys Ed.) M. App. Sc (Human Movement) VU

Ms K Mumford B. Sc (Clin. Sc) VU

Victoria University City Campus , Department of Health Sciences, 301 Flinders Lane Victoria, Australia 3000. Address e-mail to pat.mclaughlin@vu.edu.au.

Human Research Ethics Committee, Victoria University, PO Box 14428, MCMC Melbourne 8001.

ABSTRACT

Study Design: Replication of joint position and reporting of error terms in subjects with chronic ankle sprain.

Objective: To examine if subjects with chronic ankle inversion injuries have worse proprioception in the inversion/eversion plane, when compared to a control ankle and to examine whether taping the ankle improves proprioception.

Background: The most common sporting based injuries are to the ankle. The correct instruction for rehabilitation may decrease the risk of reoccurrence.

Methods and Measures: Subjects included 20 physically active adults (4 men, 16 women) with a mean age of 23.33 (± 2.66) years. Participants were divided into 2 groups: Standard Taping Technique (Group 1) and Gibney Taping Technique (Group 2). All subjects had unilateral chronic inversion injuries, having had at least three ankle inversion sprains within the last 2 years, yet not within the 5 weeks before testing. The participant's asymptomatic ankle was used as a control.

We assessed prioprioception using a kinesthiometer (purpose built). Active joint angle replication was assessed at the ankle in the inversion and eversion plane under two different taping techniques.

Results: We analysed the data using three types of re-positioning errors: the absolute, exact and variable error. Data analysis indicated a greater exact error with active angle replication for the previously injured ankle in the inversion plane, for both groups. The majority of exact error was related to a tendency to overshoot from the test position. Taping did not appear to enhance proprioception at the ankle once activity was introduced.

Conclusions: We suggest that the possible cause of recurrent ankle sprains in the inversion plane is due to diminished proprioception of the injured limb. Therefore, we give emphasis to the importance of proprioceptive training in the rehabilitation of ankle injuries.

Related Words: position sense, ankle inversion sprain, strapping, rehabilitation.

INTRODUCTION

Ankle sprains are among the most common sports injuries, accounting for 10-30% of all musculokeletal injury. Of these, the acute lateral ankle sprain is the most prevalent, with an incidence as high as 85% of sports related ligamentous injury.[4]

In spite of numerous clinical trials and basic scientific research, the occurrence rate for these injuries remains high.[11,12,28] Although there is still uncertainty as to why these sprains continue to occur, factors such as deficits in proprioception, Chronic Ankle Instability (CAI), mechanical instability, and delayed peroneal reaction time or weakness have been implicated by previous researchers.[1,28]

Proprioception is the collective term used to describe a group of sensations; encompassing the sense of movement, position of joints and sensations which relate to muscular force.[24] There are three classes of proprioceptive inputs that contribute to provide signals for postural control. These afferent (input) receptors arise from 1) muscular tissues, 2) cutaneous tissues and, 3) ligaments and joint capsules.

Freeman et al[8] that joint afferents, located in supporting ligaments, are disrupted as a consequence of ankle injury. Therefore, proprioceptive deficits are likely to occur following injury to musculotendonous and nervous tissue, and hence, contribute to a reduced position sense. The ability to detect motion in the foot and make postural adjustments both before and during foot contact is thought to be crucial in preventing ankle injury.[18,28] Hence, ankle inversion sprains may occur because of incorrect foot positioning due to a loss of proprioceptive input from mechanoreceptors at the previously injured site.

Proprioception is frequently measured via joint position sense, using either active or passive joint angle replication.[3,11,12] However, previous studies assessing CAI provide conflicting results.

Glencross and Thornton[11] performed a trial examining active angle replication in the plantarflexion and dorsiflexion plane in their methodology. The authors reported a significant difference between a subjects ability to reposition the injured limb, compared to the uninjured one. In contrast, Gross[12] and Holme[15] reported no significant difference between the injured and uninjured ankles for either active or passive joint angle replication measurements.

Authors of various sporting backgrounds advocate taping in the management of both acute and chronic phases of ankle injury[4,24,25]. The implementation of external ankle support into an athlete's post-injury regime is believed to control swelling and range of motion in the acute stage, and provide support and stability to ligamentous structures as well as joint connective tissues in more chronic phases.[4]

Rationale for the prophylactic properties of taping is centered on two main theories: 1) mechanical restriction of ankle joint motion, and 2) enhanced neuromuscular response.[2]

It has been speculated that external support, such as that provided by adhesive tape, could provide a cutaneous prompt either directly or indirectly via facilitation of muscular afferents.[24] On movement, cutaneous cues surrounding the ankle complex are brought about with the traction of ankle tape. The tape is thought to unite the skin of the foot with the lower leg. Athletes use this stimulation to improve position sense and the orientation of their foot in anticipation of the contact surface.[25] The trial by Robbins[25] on foot position, reported that ankle taping might have a place as a prophylactic measure of ankle sprains in athletes.[25] Their results indicated that taping improved proprioception at the ankle, both before and after exercise. However, previous studies[13,18] failed to detect any significant difference in proprioception when analysing the taped and untaped ankles.

In light of this, most investigations[1,13,24,25] into the effects of ankle taping on proprioceptive awareness have been centred on the same hypotheses. Researchers[1,13,24,25] believe that the impact of initial trauma and sprain impairs proprioception, and leads to the recurrence of ankle inversion sprains. This is based on the principle that the original sprain disrupts the joint's mechanoreceptors and reduces proprioceptive capabilities. The lack of proprioception is said to predispose the ankle joint to further injury in the event of trauma.[24]

Adhesive taping techniques have been suggested to play a role in improving the functional stability of the post-traumatic ankle. It is suggested that taping stimulates the neuromuscular mechanisms by exciting cutaneous input and, indirectly, heightens muscular responses.[4]

Underlying all of these studies is the common belief that taping stimulates the proprioceptive cues necessary to keep the ankle in a state of balance and control. Moreover, previous researchers[4,5] have indicated that the lasting affects of any proprioceptive advantage from taping diminished after short periods of vigorous exercise. Research indicates that perspiration at the ankle joint during exercise reduces the stabilising and elastic effects of the tape.[5]

The taping procedures used in previous studies are significantly different to those employed by amateur sporting clubs. This study aims to utilise a safe and secure measurement protocol to compare a standard taping technique with a more advanced "Gibney" taping technique, as documented in Hamer et al[13].

Considering that the most common risk factor for ankle sprain is a previous sprain[4], it was important for us to include subjects with a history of previous injury. The purpose of our research was to determine the effects that taping has on proprioceptive acuity in chronically injured ankles in the inversion-eversion plane. We also aimed to determine if proprioception would decline after activity, due to reduced elasticity and musculocutaneous cues from the taping. In addition, our research aimed to explore whether a more complicated taping technique would reduce variability in the injured and control ankles, compared to a simple taping technique.

METHODS

Twenty (n=20) physically active adults (4 men, 16 women) with a mean age of 23.33 (± 2.66) years volunteered for this study. Before testing, participants underwent a comprehensive medical questionnaire to establish their injury history. Volunteers with recurrent and chronic ankle inversion sprains met certain inclusion criteria: at least 3 ankle sprains, at least one of which has occurred in the preceding 2 years; yet no sprain within the previous 3 weeks. Ankle inversion sprains had to be unilateral. The second, uninjured ankle was used as a control. Ankle sprains were specifically chronic, as ankle inflammation and swelling of any acute injury could bias the results. Participants were to shave their ankles 48 hours before testing so that the adhesive tape could be directly applied to the skin. Criteria for exclusion included: subjects with a sustained fracture or neurological deficit in the limb to be tested. A lower limb neurological scan was performed to determine any interference with the subject's normal proprioceptive acuity. Subjects were free from any trouble with vestibular control and/or peripheral nerve defects. Participants had no history of surgical intervention to the ankle complex.

Two groups were allocated for each taping procedure according to a matching of age, height, weight and level of physical activity. The standard ankle-taping group (group one) consisted of 10 females. The Gibney ankle-taping group consisted of 4 males and 6 females. Mechanical instability of the subject's ankles was not measured. Each volunteer signed an informed consent and the study was approved by the Ethics Committee of Victoria University. All participants were required to read an information sheet at least 48 hours before testing was to commence.

MEASURES:

All Experiments were designed to test the proprioceptive acuity on

i) recurrent ankle inversion sprain,

ii) taping of the ankle.

Subjects were not informed of the experimental hypothesis, nor were they given any feedback on their performance for either pre or post exercise testing.

APPARATUS

Equipment:

- Portable Kinesthesiometer to passively induce inversion and eversion to the ankle (Purpose built by VU, see Figure 5)
- Goniometer to measure joint angles
- Athlegen sports massage table and protective floor mat.

Ankle supports:

Strapping tape was provided by Leuko sportstape. The tape used was an adhesive, rigid, non-elastic zinc-oxide tape of 38mm in width. This is the standard ankle tape used by competitive athletes.

Tape was applied to group one using a series of 3 stirrups, a "6" and a heel lock.

These taping techniques have previously been shown to provide significant ankle restriction for both the inversion and plantarflexion movements (see Figure 6). A second taping procedure known as the Gibney Technique was used on group two, as it is a widely accepted and documented taping procedure [13] (see Figure 7) Participants had both ankles taped using the same technique, as a means for comparison between a chronically injured and uninjured ankle. Both taping techniques were adapted from Macdonald.[20]

PROCEDURE

Testing was carried out in the Victoria University Biomechanics Laboratory. The room was darkened to minimise any external visual stimuli and aid concentration. Similarly the environment was quiet to discourage any auditory distraction that may disrupt the participants focus to actively replicate the test angle.

Subjects were placed supine on an athlegen sports table, with their foot resting in the kinethesiometer. The kinesthesiometer was placed at the table's end. The volunteers were required to close their eyes whilst the subtalar joint was placed in both five degrees of ankle inversion and five degrees of ankle eversion. The lower leg and dorsum of the foot was secured by velcro-adhesive straps to the measuring device. Each position was passively held for five seconds, then returned back to neutral for a latent period of three seconds. Volunteers were instructed to concentrate on the test position of the foot. Subjects were then required to replicate these joint angles using proprioceptive cues. On both passive joint positioning and active joint replication, the joint angle was measured and recorded using the Kinesthesiometer. Any discrepancy between the two trials was recorded as degrees of exact error. Each trial was performed once for each ankle in both inversion and eversion to avoid familiarisation. The testing order of angle and side of the body was randomly chosen. Four sets of measurements were taken:

1) before the application of tape
2) after the application of tape, yet before physical activity
3) after 10 minutes of physical activity
4) after a further 10 minutes of physical activity.

The exercise course was laid out in an adjacent room. Markers were set in place to indicate the direction the participant must follow, when walking at a vigorous pace of approximately 60% of maximal rate of perceived exertion (RPE). The dimensions for this course were adapted from Hamer et al[13] and is depicted in Figure 8.

Participants were tested in their allocated groups on separate days. It was anticipated that the testing protocol would take each subject approximately 30 minutes to complete. Subjects were instructed to arrive at half-hourly intervals to be prepared before measurement commenced.

DATA ANALYSIS

Willems et al[28] reported that the most appropriate statistics for analysing proprioception are re-positioning errors. Three types of re-positioning errors were examined for the subject's ability to match the reference angles: The absolute, exact and variable error.

- The absolute error is the absolute difference in degrees between the position chosen by the subject and the test-position angle. The absolute error is expressed as the number of degrees between the test position and the chosen position on active angle replication. That is if the test position is five degrees (5°) inversion, and the chosen position is two degrees (2°) inversion, then the absolute error is three degrees (3°).
- The exact error is the difference between the chosen position and the test-position and takes into account an overshoot (positive) or undershoot (negative) on the test-position angle. The exact error is expressed as the mean re-positioning difference. That is if the test position is five degrees (5°) inversion, and the chosen position is two degrees inversion (2°), the exact error is negative three degrees (-3°).
- The variable error was recorded as the standard deviation of the exact error and provides an indication of any random error in replicating the test-position angle.[28]

Microsoft Excel 98 was used for the statistical analysis. The exact, absolute and variable data from the proprioception test were used to determine the differences between the two groups.

RESULTS

STANDARD TAPING TECHNIQUE

For the Absolute error, a greater error occurred on the control side when taping was applied, than compared to the injured ankle, in both inversion (0.9 vs 0.65) and eversion (0.55 vs 0.45) (see Table 1 and Table 2). For the exact error, the previously injured ankle recorded consistently more inaccurate results when inverting the foot (see Figure 1). In contrast, it was the control group that became more inaccurate when everting the foot, after both exercise bouts (-0.4; -0.1 vs 0.15; 0.05)(see Table 2). In both instances, a higher exact error was associated with undershooting from the test position (see Figure 1 and Figure 2). No notable differences were observed for the variable error among the groups.

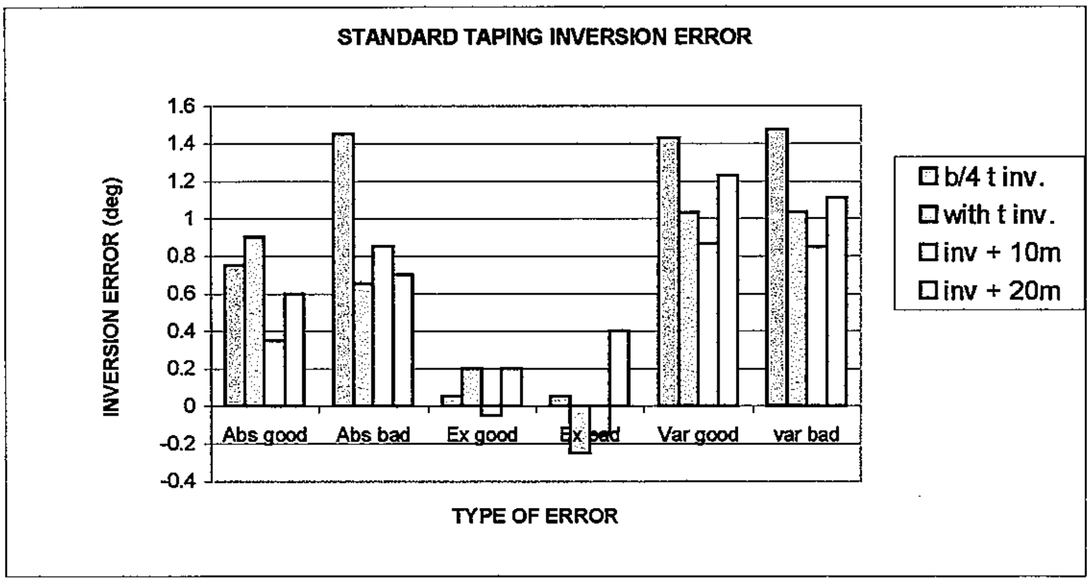

FIGURE 1: Inversion Error using a Standard taping Technique

Abs = Absolute error; Ex = Exact error; Var = Variance; Good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

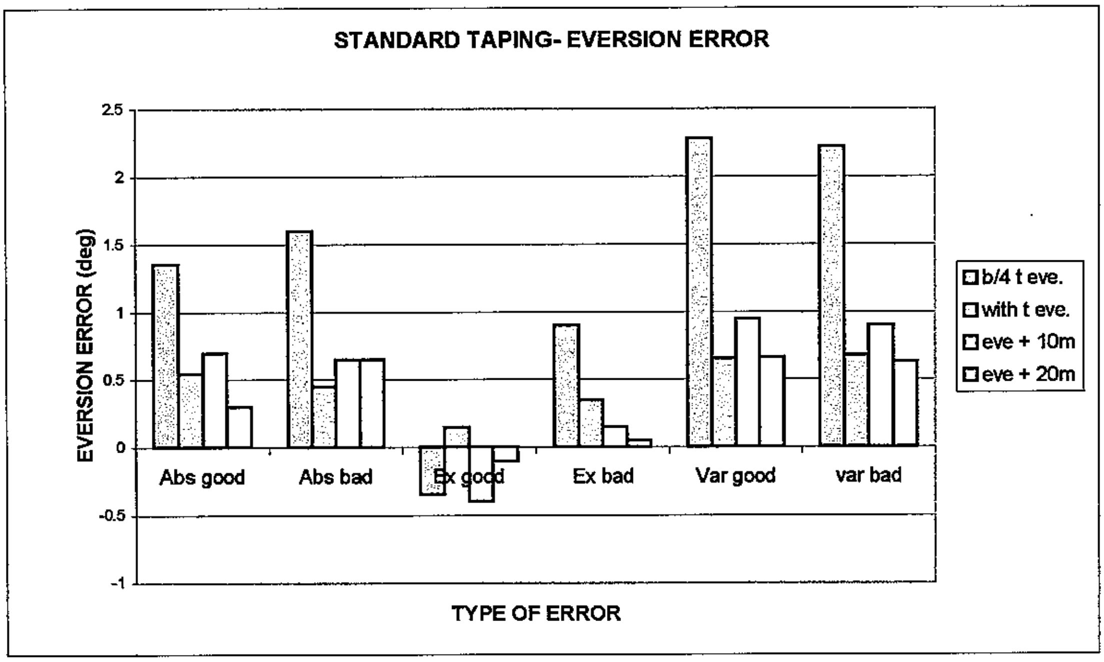

FIGURE 2: Eversion Error using a Standard Taping Technique

Abs = Absolute error; Ex = Exact error; Var = Variance; Good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

GIBNEY TAPING TECHNIQUE

For the absolute error, a greater inversion and eversion error occurred in the previously injured ankle, in all conditions, when compared to that of the control (see Table 3 and Table 4). The degree of absolute eversion error on the previously injured ankle consistently decreased with taping, then activity. The control group yielded the most accurate absolute error results after taping and 10 minutes of exercise in inversion (0.35 vs 1.35) and eversion (0.1 vs 0.9). For the exact error, a greater inversion and eversion error existed for the previously injured ankle, in all conditions, when compared to that of the control (see Figure 3 and Figure 4). Exact error of the previously injured ankle gradually increased over time with eversion recordings. Exact error of the formerly injured ankle was always recorded as overshooting from the test position (see Figure 3 and Figure 4). Exact error of the control ankle began to undershoot in the inversion test position after activity. No statistical difference was recorded between the groups for variance in the inversion test position. Variance for the groups in the eversion test position were not statistically different from one another, and both gradually reduced over time.

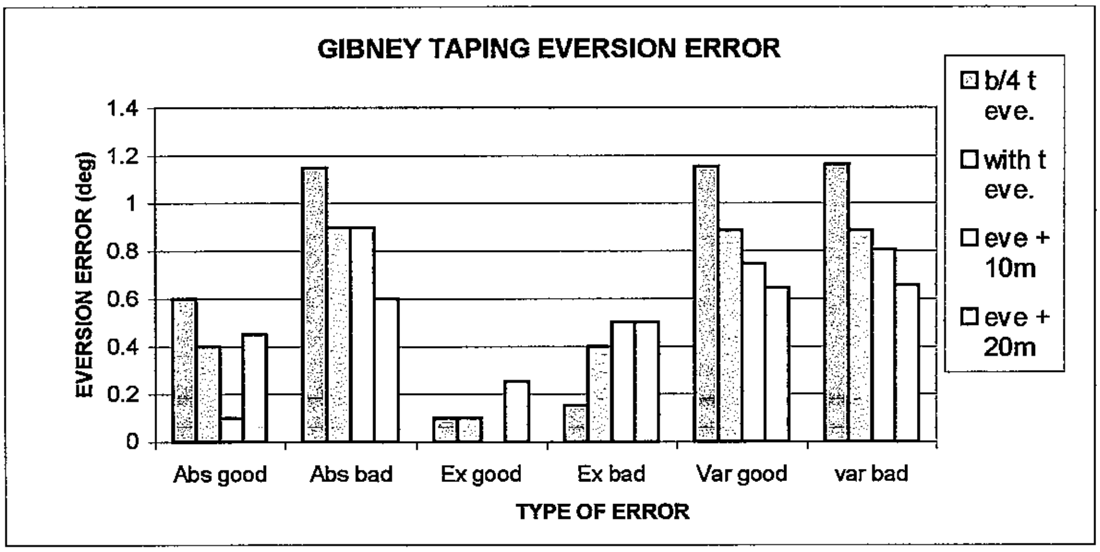

FIGURE 3: Inversion Error using the Gibney Taping Techhnique

Abs = Absolute error; Ex = Exact error; Var = Variance;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

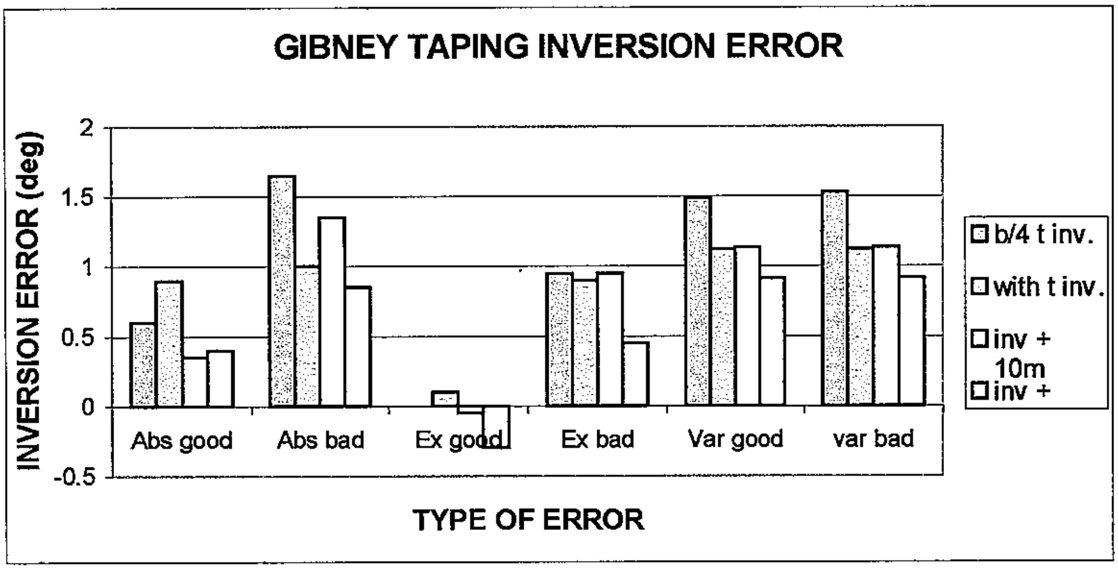

FIGURE 4: Inversion Error using the Gibney Taping Technique.
Abs = Absolute error; Ex = Exact error; Var = Variance;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

DISCUSSION

It is a commonly accepted belief that ankle sprains occur due to a proprioceptive deficit caused by deafferentation, during trauma.[28] Common methods cited for assessing ankle proprioception include a modified Rhomberg (one-legged stance) test, one legged wobble board stance and force platform analysis of postural sway (centre of pressure and ground reaction forces).[2] These techniques, however, do not isolate any variation in ankle performance due to factors such as visual, vestibular or neuromuscular cues. The only advantage of these techniques is that they are tested in a weight-bearing position. From an orthopaedic perspective, peripheral mechanoreceptors are the most important component of proprioception when assessing cutaneous, muscle and joint function at the ankle complex, following injury. The reproduction of joint position, either active or passive, can objectively isolate the measurement of joint position at the ankle. This study involved a procedure that stimulated common mechanisms of injury to the ankle joint: eversion and inversion.

Results were analysed using two different types of error: the absolute and exact error. The absolute error has been used in the vast majority of previous investigations into proprioception. [3,11,15] Our results for the exact error varied according to the taping method used. The previously injured ankle produced a statistically greater absolute error when strapped using the Gibney technique, in both test positions. Similarly, Glencross and Thornton[11] reported post-injury deficits in active joint position sense. However, analysis was carried out in the plantarflexion-dorsiflexion plane. In contrast, Gross et al[12] and Holme et al[15] noted no significant difference between the absolute error of their controls and subjects with recurrent ankle sprains when testing active joint position sense in the inversion – eversion plane. Importantly, the ankles in these previously reported studies were not taped.

The added advantage of recording an exact error takes into account any tendency to overshoot or undershoot the test-position. In this study, the exact error was usually positive, indicating a bias to overshoot the reference angle. The findings for the control groups of this research are in support of Feuerbach et al[6], who reported that exact error was not significantly different from zero in subjects without injuries in the inversion plane.

In contrast, Willem et al[28] noted a significant difference in the exact error for active joint position sense in a test for inversion. The authors reported that subjects with unstable ankles had a less accurate exact error for active joint position sense at maximum inversion, minus 5 degrees (-0.68$\pm$ 3.21 vs –5.93 $\pm$ 6.68). The authors also noted that past ankle sprains without instability did not affect an individuals ability to judge ankle position sense (0.10 $\pm$ 2.47). The authors concluded that the proprioceptive deficit was highly correlated with recurring ankle sprains in subjects with CAI. Hartsell[14] concluded that subjects with CAI had poorer active joint position than those of the control, when testing in the inversion plane at 15 degrees. Similarly, Jerosch and Bischof[16] reported an increased absolute error when replicating ankle inversion angles (3`, 15` and 20`) in subjects with unilateral CAI when comparing the stable and unstable sides. Chronic Ankle Instability (CAI) was not assessed in our study, and may be a reason for our conflicting results. In addition, previous researchers have measured active joint position using greater angles than those in our study. This may explain why such a small amount of error was recorded in our results.

Our results indicate that ankles with previous inversion injury are statistically less accurate than the control ankles, when replicating an active joint position angle in the inversion plane. These results concur with previous literature which suggests that hitting the ground in an overly inverted position can result in reinjury, due to proprioceptive deficit .[28] noted that a deficit in joint position sense in subjects with CAI may be counterbalanced by the affects of taping or bracing. Similarly, previous studies suggest that taping and bracing reduce error in position sense.[6,14] Our results indicated a reduction in error may be attributed to the initial application of adhesive tape, using a standard taping procedure, when measuring active joint angle replication in the eversion plane. Similar results were reported from our study with the application of a Gibney taping technique to 1) a previously injured ankle, when proprioception in the inversion plane was measured, and 2) a control ankle, when proprioception in the eversion plane was measured. The application of the adhesive tape may indicate an increase of afferent feedback from cutaneous receptors, hence, increasing active ankle joint position sense. Our contention that a taping technique would highten afferent sensitivity and reduce variance amongst groups was supported by our data. However, variance was reduced by a greater degree when simply using a standard taping technique.

Previous researchers[7,23] claimed that a reduction in the restraining effects of taping ranged between 40-50% after 10-15 minutes of jumping, pivoting and running, respectively. Furthermore, the elastic effects of taping have been said to diminish over these periods of activity. Frankney et al[7] implied that the restricting affect of taping subsequently lost after 15 minutes of standard, vigorous exercise may contribute to a reduction in proprioception. Our results were not in support of these findings. The absolute error of the previously injured ankle was immediately decreased following the application of tape, in both eversion and inversion. However, the absolute error began to increase with the introduction of exercise.

LIMITATIONS AND RECOMMENDATIONS:

MEASUREMENTS

Joint angles were measured using a newly built kinesthiometer. In some cases, active joint angle replication was difficult, as the recently manufactured device was quite stiff. The purpose built kinesthiometer was placed into a passive joint angle by a researcher. However, the speed at which the researcher passively positioned the ankle was not measured. For future research, a kinesthiometer should be manufactured from material with a reduced friction force. The test position motion should be moved at a constant angular velocity to reduce kinesthetic bias.

The mechanism said to be the most responsible for injuring the lateral ligaments of the ankle occurs with a combination of slight plantarflexion and excessive inversion.[27] The inversion and eversion angles reproduced in this research were quite small so error was minimal. For future research, greater angles may need to be used to provide a better indication of proprioception at full range of motion. Similarly, angles may need to be measured in the plantarflexion/ dorsiflexion plane for a more thorough analysis of proprioception at the ankle.

PARTICIPANTS:

Participants were instructed to exercise at 65% of their maximal rate percieved exertion (RPE). The variation in perception of exercise intensity would place different forces through the tape and potentially bias results. Future researchers may need to control activity so that all participants undertake exercise at the same intensity and complete a similar number of repetitions around the circuit.

Participants were not examined for muscle strength or CAI prior to trials. However, previous research indicates that proprioception deficit is associated with eversion strength and ankle instability. Any future research should take into account evertor muscle contraction strength and ankle instability to reduce any bias of results.[26,28]

CONCLUSION

Chronic ankle inversion sprains were related to an absolute error in active joint angle replication of five degrees inversion, when compared to the control ankle. The previously injured ankle recorded more inaccurate exact error than the control, in matching the inversion test position, regardless of the taping technique used. Overall, error related to a tendency to overshoot from the test position. Regardless of the taping technique employed, variance was immediately reduced amongst all groups. Taping did not appear to enhance proprioceptive capabilities in the ankle once activity was introduced.

Our research indicates that proprioception is reduced in the previously injured ankle. These results reaffirm the importance of proprioceptive training in the rehabilitation of ankle injuries. Our findings also suggest that a possible cause for these recurrent ankle sprains is diminished proprioception of the injured limb. Athletes with previous ankle inversion injury exhibit a tendency to overly invert the ankle. Excessive ankle inversion at the moment of foot contact predisposes the ankle to further injury of the lateral ligaments. This may explain why recurrent ankle inversion injuries continue to occur.

References:

1.**Alt, W., Lohrer, H., Gollhofer, A.** Functional properties of Adhesive ankle taping: Neuromuscular and mechanical effects before and after exercise. *Am Orthop. Foot Ankle.* 1999. **20**: 238-45.

2.**Bennell, K.L., Goldie, P.A.**; The differential effects of external ankle support on postural control.1994. *J Orthop. Sports Phys. Ther.*, **20**:287-95.

3.**Boyle, J., Negus, V.** Joint position sense in the recurrent sprained ankle. *Aust J Physiother.* 1998. **44**: 159-163.

4. **Callaghan, M.J.** Role of ankle taping and bracing in athlete. *Br J Sports Med.* 1997. **31**: 102-8.

5.**Ferguson, A.B Jr.**; The case against ankle taping. *J Sprots Med.*1973. **1** (2), 46-47.

6.**Feuerbach, J.W., Grabiner, M.D., Koh, T.J., Weiker, G.G**: Effect of ankle orthosis and ankle ligamnet anesthesia on ankle proprioception. *Am J Sports Med.* 1999. **22**: 239-229.

7.**Frankney JR, Jewett, DL, Hanks GA, Sebastianelli WJ**; A comparison of ankle tape and methods. *Clin J Sports Med.* 1993. **3**:20-5.

8.**Freeman, M.A., Dean, M.R., Hanham, I.W**; The etiological prevention of functional instability of the foot.*J Bone Joint Surg Br.* 1965. ***35*** 678-685

9.**Garrick, J.G.**; the frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *Am J Sports Med.* 1998. **4**:136-141

10.Garrick, J.G. and Requa, R.K.; The epidemiology of foot and ankle injuries in sport. In Yokum L, ed. *Clinics in sports medicine: foot and ankle injuries*. 1998. Philadelphia: W B Saunders, 29-36.

11.Glencross D, and Thornton,E; position sense following joint injury. *J Sports Med and Phys Fitness*. 1981. **21**: 23-27.

12.Gross, M.T. Effects of recurrent lateral ankle sprain on active and passive judgements of joint position. *Phys Ther*. 1987. **67**: 1505-1509.

13.Hamer, P.W., Munt, A.M., Harris, C.D., James, N.C.; The influence of ankle strapping on wobbleboard performance, before and after exercise. *Aust J Physio*. 1992. **38**: 85- 92.

14.Hartsell, H.D.: The effects of external bracing on joint position sense awareness for the chronically unstable ankle. *J Sports Rehabil*. 2000. **18**: 279-289.

15.Holme, E., Mangusson, S.P., Becker, K., Bieler, T., Aagaard, P., Kjaer,M. The effect of supervised rehabilitation on strength, postural sway, position sense and re-injury risk after ankle ligament sprain. *Scand J Med Sci Sports. 1999.* **9**: 104-109.

16.Jerosch, J., Bischof, M.; Proprioceptive capabilities of the ankle in stable and unstable joints. *Sports Exerc Inj*. 1996. **2**: 167-171.

17.Karlsson, J and Andreasson, G.O.; the effect of external ankle support in chronic lateral ankle joint instability. *Med Sci Sports Exerc*. 1992. **20**, 257-261.

18.Kinzey, S.J., Ingersoll, C.D., Knight, K.L.; The effects of selected ankle appliances on postural control. *J Ath. Train*. 1997. **32**: 300-3.

19.Lynch, S. & Renstrom, P.; Treatment of acute lateral ankle ligament rupture in the athlete: Conservative versus surgical treatment. *Sports Med*. 1999. **27** (1): 61-71.

20.Macdonald, R. *Taping Techniques - Principles and Practice.* Butterworth-Heinemann. 1998

21.Norkin,C. & Levangie, P. *Joint Structure & Function. Philadelphia.* F.A. Davis Company. 1992

22.Pope, M.H., Renstrom, P. and Donnermeyer D.; A comparison of ankle taping methods. *Med Sci Sports Exerc.* 1987. **19**: 143-147.

23.Rarick, G., Bingley, G., Karst, R. and Malina, RM.: The measurable support of the ankle joint by conventional methods of taping. *J Bone Joint Surg.* 1962. **44**, 1183-1190.

24.Refshauge, K.M., Kilbreath, S.L., Raymond, J.; The effect of recurrent ankle inversion sprain and taping on proprioception at the ankle. *Med. Sci. Sports. Exer.* 2000 .**32**: 10-15.

25.Robbins S., Waked, E. and Rappel, R.; Ankle taping improves proprioception before and after exercise in young men. *Br. J. Sports Med.* 1995. **29** (4), 242-247.

26.Tropp, H., Askling, C., Gillquist, J. Prevention of ankle sprains. *Am J Sports Med.* 1985. **13**: 259-262.

27.Verbrugge, J.D.: The affects of semi-rigid aircast airstirrup bracing vs. adhesive ankle taping on motor performance. *J Orthop Sports Phys Ther.* 1996. **23**: 320-325.

28.Willems, T., Witvrouw, E., Verstuyft, J., Vaes, P., De Clercq, D. Proprioception and muscle strength in subjects with a history of ankle sprains and chronic instability. *J Athl Train.* 2002. **37** **(4)**: 487-493.

TABLE 1: Inversion Error for the Standard Taping Group on Active Angle Replication.

	b/4 t inv.	with t inv.	inv + 10m	inv + 20m
Abs good	**0.75**	**0.9**	**0.35**	**0.6**
Abs bad	1.45	0.65	0.85	0.7
Ex good	**0.05**	**0.2**	**-0.05**	**0.2**
Ex bad	0.05	-0.25	-0.15	0.4
Var good	**1.43**	**1.03**	**0.86**	**1.23**
var bad	1.47	1.03	0.85	1.11

Abs = Absolute error; Ex = Exact error; Var = Variançe;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

TABLE 2: Eversion Error for the Standard Taping Group on Active Angle Replication.

	b/4 t eve.	with t eve.	eve + 10m	eve + 20m
Abs good	**1.35**	**0.55**	**0.7**	**0.3**
Abs bad	1.6	0.45	0.65	0.65
Ex good	**-0.35**	**0.15**	**-0.4**	**-0.1**
Ex bad	0.9	0.35	0.15	0.05
Var good	**2.28**	**0.65**	**0.95**	**0.66**
var bad	2.22	0.67	0.90	0.63

Abs = Absolute error; Ex = Exact error; Var = Variance;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

TABLE 3: Inversion Error for the Gibney Taping Group on Active Angle Replication.

	b/4 t inv.	with t inv.	inv + 10m	inv + 20m
Abs good	**0.6**	**0.9**	**0.35**	**0.4**
Abs bad	1.65	1	1.35	0.85
Ex good	**0**	**0.1**	**-0.05**	**-0.3**
Ex bad	0.95	0.9	0.95	0.45
Var good	**1.49**	**1.12**	**1.13**	**0.91**
var bad	1.53	1.12	1.14	0.92

Abs = Absolute error; Ex = Exact error; Var = Variance;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

TABLE 4: Eversion Error for the Gibney Taping Group on Active Angle Replication.

	b/4 t eve.	with t eve.	eve + 10m	eve + 20m
Abs good	**0.6**	**0.4**	**0.1**	**0.45**
Abs bad	1.15	0.9	0.9	0.6
Ex good	**0.1**	**0.1**	**0**	**0.25**
Ex bad	0.15	0.4	0.5	0.5
Var good	**1.16**	**0.89**	**0.75**	**0.65**
var bad	1.16	0.89	0.81	0.66

Abs = Absolute error; Ex = Exact error; Var = Variance;good = control ankle; bad = previously injured ankle; b/4 t eve = before taping; with t = with taping, before activity; eve + 10m = with taping and 10 minutes activity; eve + 20m = with taping and 20 minutes activity.

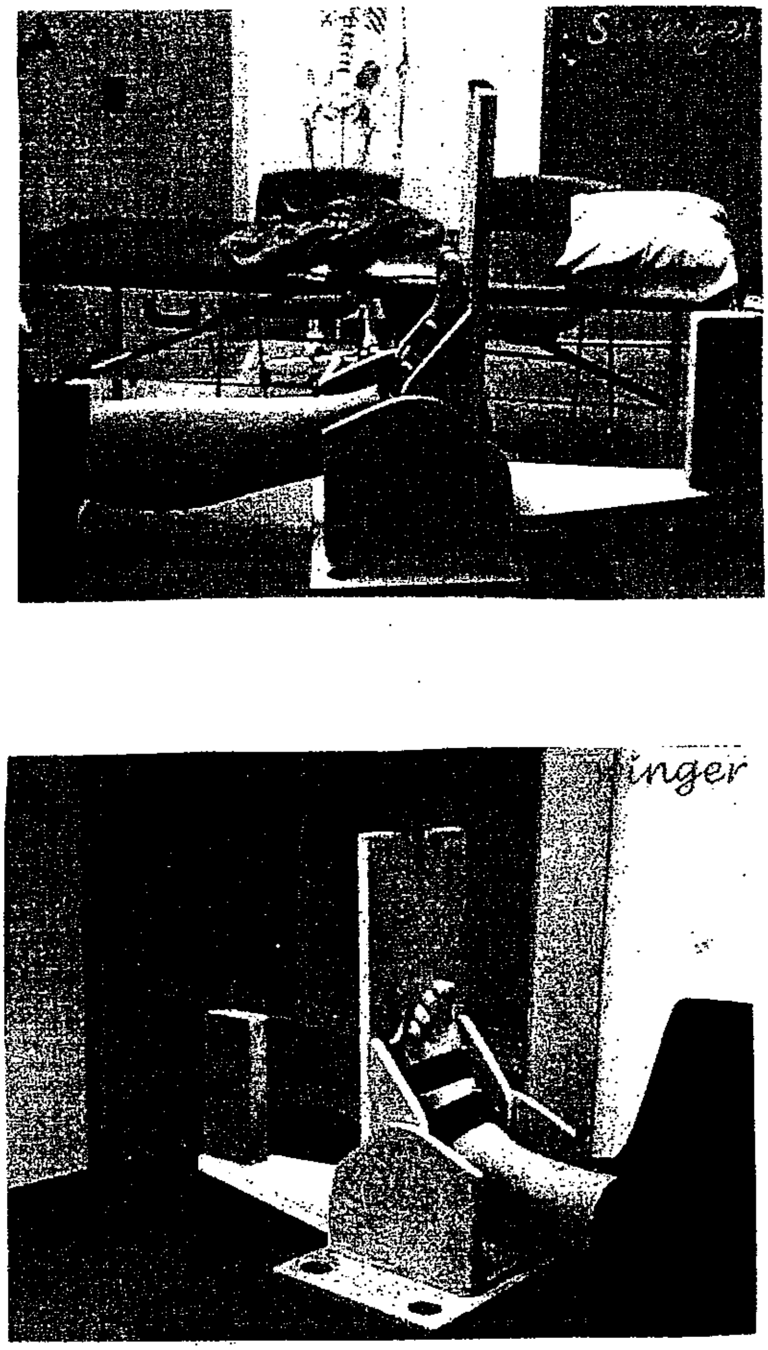

FIGURE 5: Positioning of the subject for testing active joint angle replication on the kinesthesiometer. A. left medial view. B. Left Oblique View

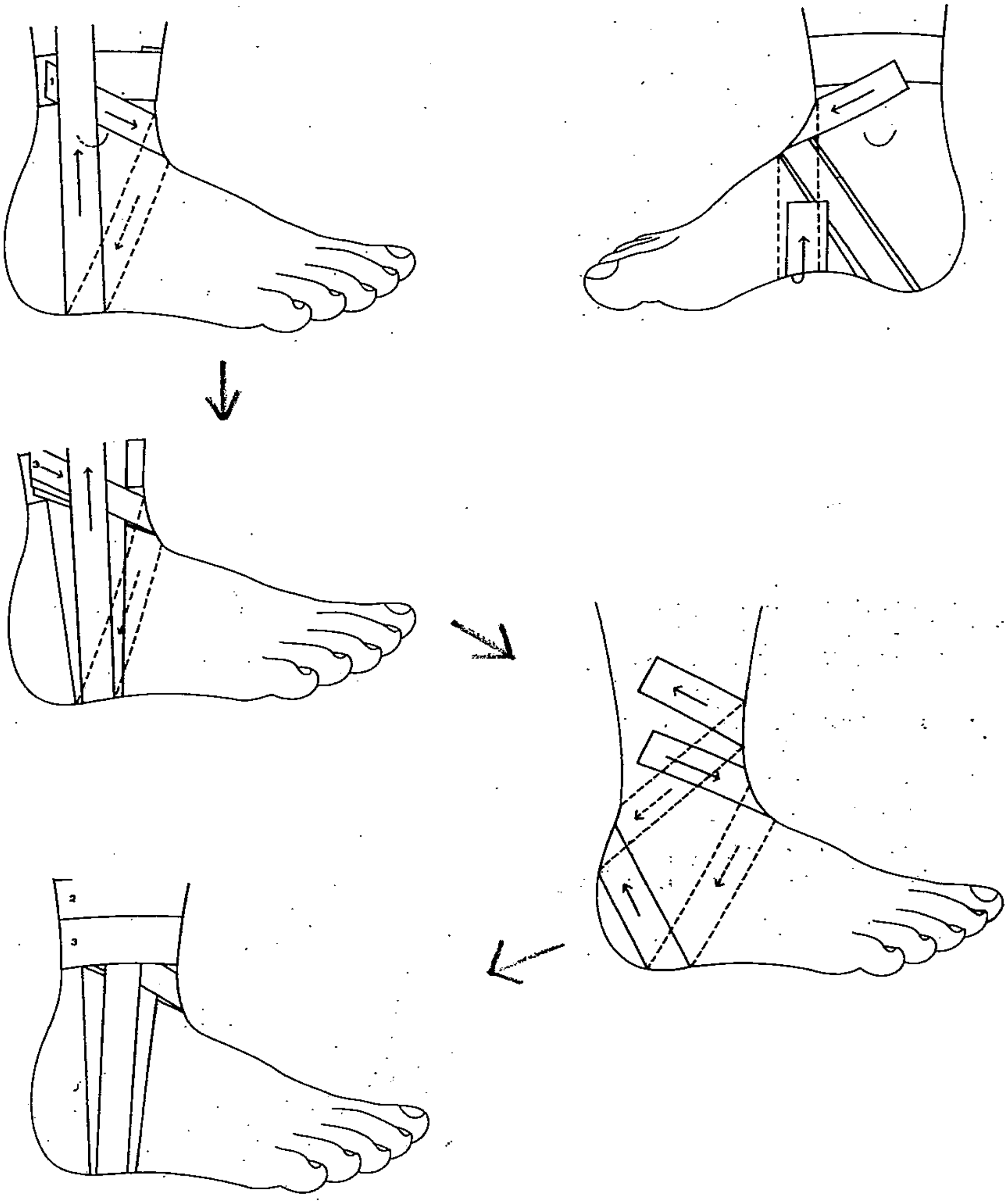

FIGURE 6: Standard taping technique with a series of 3 stirrups, a figure "6" and a heel lock.

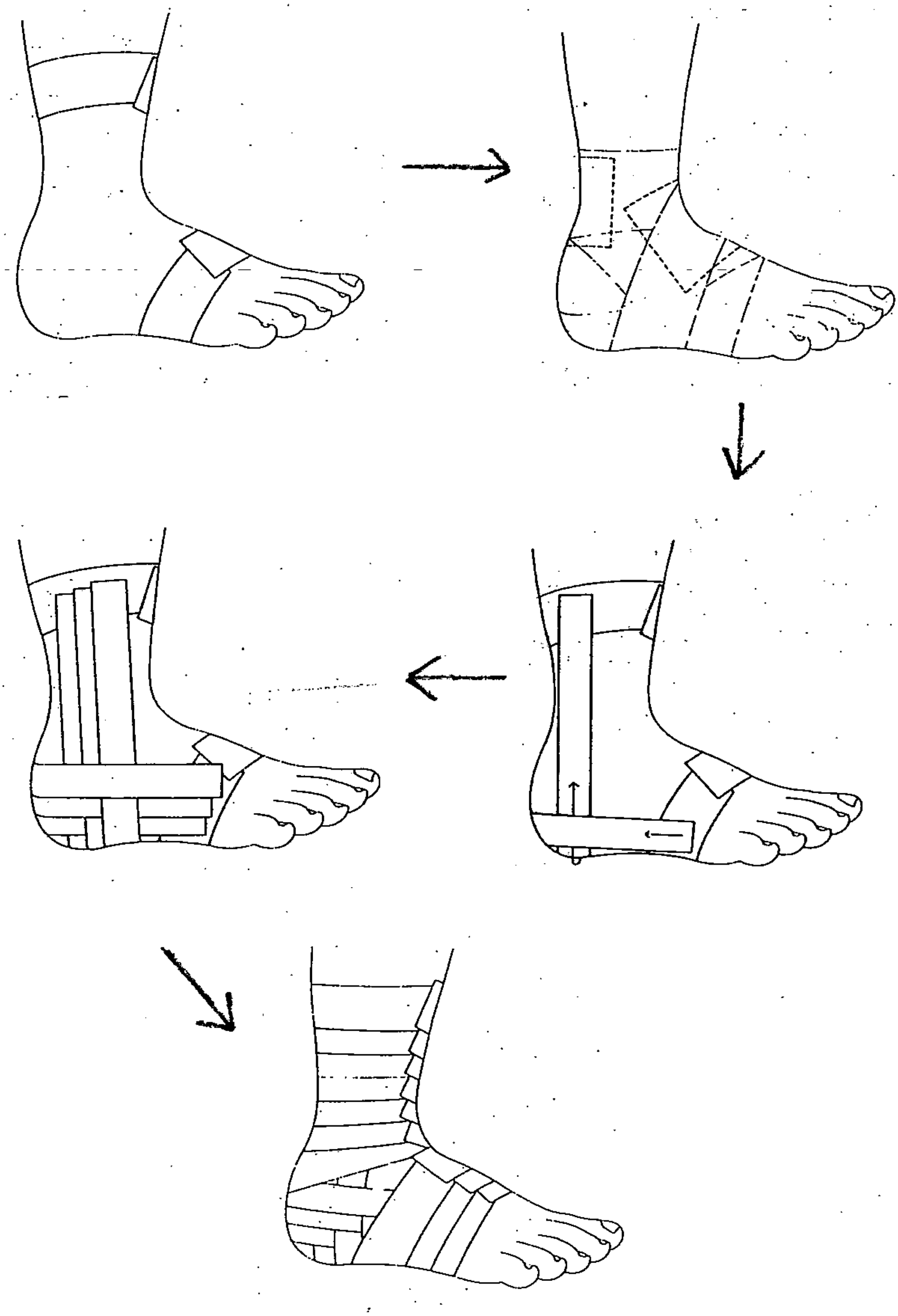

FIGURE 7: Gibney taping technique with a series of alternating stirrups and horizontal strips.

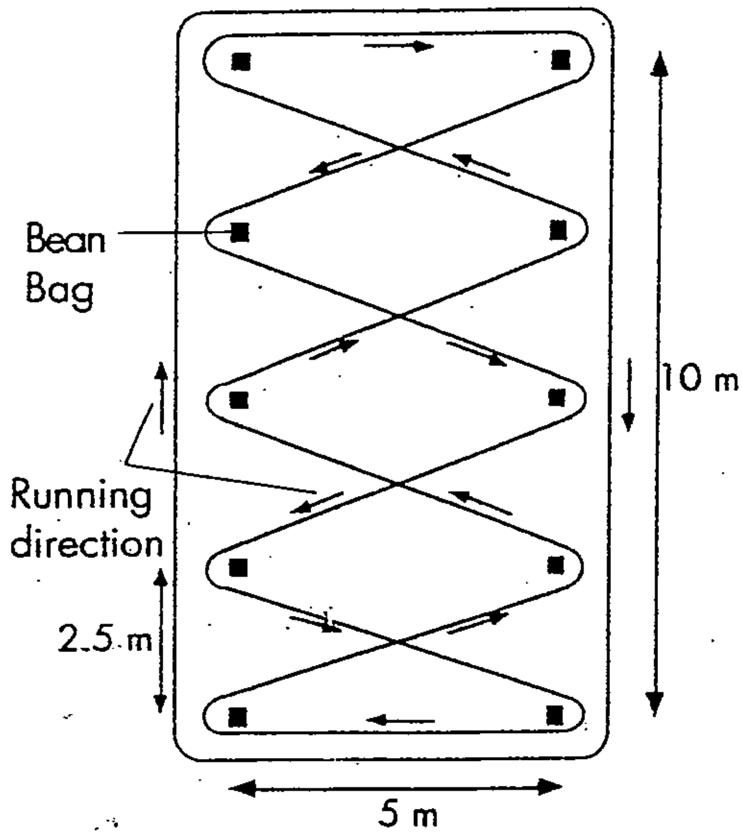

FIGURE 8: Diagram of Exercise Course.