The Effect of Ankle Bracing and Taping on Joint Position Sense in the Stable Ankle

Eric J. Heit, Scott M. Lephart, and Susan L. Rozzi

The purpose of this study was to determine the proprioceptive effects of ankle bracing and taping. Proprioception was assessed in 26 subjects by evaluating ankle joint position sense, which was determined by the subjects' ability to actively reproduce a passively positioned joint angle. Testing was performed at positions of 30° of plantar flexion and 15° of inversion. Each subject underwent four trials at each test angle under three conditions: braced, taped, and control. For the plantar flexion test, both the braced condition and the taped condition significantly enhanced joint position sense when compared to the control condition. There was no significant difference between the braced and taped conditions. For the inversion test, the taped condition significantly enhanced joint position sense compared to the control condition. There was no significant difference between the braced and the control conditions or between the braced and the taped conditions. This study demonstrates that ankle bracing and taping improve joint position sense in the stable ankle.

The ankle joint is one of the most frequently injured joints of the human body (10, 11). Over the years, several techniques have been developed in an attempt to decrease the severity and incidence of lateral ankle sprains. The most frequently used and reported techniques are bracing and taping (1, 6, 9, 21, 22, 24, 26).

Two mechanisms exist by which ankle bracing and taping are theorized to prevent or decrease the incidence and severity of lateral ankle injuries. The first mechanism suggests that bracing and taping add mechanical support to the ligamentous structures and limit the extreme ranges of talar and subtalar joint motion (7, 8, 13, 22). The second theory suggests that bracing and taping may prevent injuries by enhancing proprioception and stimulating muscular control (11, 17, 23). Researchers have recently concluded that range of motion restriction may not be a reliable measurement of a prophylactic device's protective ability (1, 13). The role bracing and taping may play in preventing ankle injury by proprioceptively stimulating muscular contractions is supported by many authors (17, 23), but the scientific basis of this theory has yet to be well established through research (12, 21).

Eric J. Heit is with Henry M. Jackson High School, 1508 136th St. SE, Bothell, WA 98012. Scott M. Lephart is with Sports Medicine/Athletic Training and the Neuromuscular Research Laboratory, University of Pittsburgh. Susan L. Rozzi is a doctoral student in the Neuromuscular Research Laboratory, University of Pittsburgh. Direct correspondence to Susan L. Rozzi, 104 Trees Hall, University of Pittsburgh, Pittsburgh, PA 15261.

In normal, healthy individuals, the protective muscular reflex arc is initiated by mechanoreceptors and muscle spindle receptors. Stimulation of the cutaneous nerve receptors and/or mechanoreceptors may result in earlier and enhanced muscular contractions. An earlier onset of the joint's protective muscular contractions may possibly decrease the incidence and/or severity of an injury. The application of an ankle brace or ankle tape may provide enough stimulation of the tissue surrounding the ankle joint to stimulate ankle joint mechanoreceptors.

The purposes of this study were to determine if proprioception, quantified through the assessment of joint position sense, was enhanced by either the use of a commercially available ankle brace or by prophylactic taping when compared to an untaped/unbraced control ankle, and to compare joint position sense measurements obtained when the ankle was taped to those obtained when only an ankle brace was worn.

Materials and Methods

Subjects included 26 (10 male, 16 female) physically active college-age individuals (age 18.9 ± 0.8 years). Physically active was defined as participating in some form of physical activity for a minimum of 30 min, three times per week. At the time of the study, all subjects were free of ankle pathology and had not, within the year prior to testing, suffered an injury that limited ankle joint function for more than 48 hr. No subject reported a history of recurring ankle sprains, having had any type of ankle surgery, or having sustained a ligamentous ankle injury that was graded higher than a second-degree sprain. Based on history, all subjects were classified as possessing a functionally stable ankle. Subjects reporting any history of ankle injury were excluded from the study unless they had completed a comprehensive rehabilitation program that included a component of proprioceptive training.

Prior to participation, subjects signed an informed voluntary consent form to participate in this study, which was approved by the Institutional Review Board for Biomedical Research. Two tests of joint position sense were selected to test the following three conditions: ankle braced, ankle taped, and the unbraced/untaped control condition. For each subject, the order of administration of the six tests was determined randomly in an attempt to eliminate the confounding effects of fatigue.

Tests

Each subject was evaluated using two separate tests of joint position sensibility. For both tests, joint position sense was determined by measuring the subject's ability to actively reproduce a passively placed joint position. Testing joint position sense is one method of assessing the afferent pathway of the neuromuscular loop. Actively reproducing a previously presented joint angle within the available range of motion stimulates both joint receptors and muscle receptors. Joint position sense tested actively may better represent joint function than tests performed in the passive test mode. Tests that employ active reproduction of passive positioning have been frequently used and are accepted tests of proprioception (2–5, 14, 15).

Recently, the intertester reliability of ankle joint position sense testing was investigated. Szczerba et al. measured active and passive joint position sense in uninjured subjects using a Kinetic Communicator II (Kin–Com II) isokinetic dynamometer that had been modified for proprioception testing. Their results re-

17

vealed poor to moderate intertester reliability for both the active and passive joint position sense test protocols utilized (25). Due to the intertester reliability findings of Szczerba et al., the primary investigator performed all testing of ankle joint position sense in the present study.

For the first test, 30° of plantar flexion was selected as the test angle, while 15° of inversion served as the angle of the second test. These test angles were selected due to the varying degrees of maximal plantar flexion (28.2–45.17°) and maximal inversion (17.2–57.4°) reported in the literature for a taped or braced ankle and because the available range of motion for all subjects would be at least 15° in either direction from the test position (1, 9, 11, 26).

For both tests of joint position sense, a Cybex II® electronic goniometer (Cybex, division of Lumex, Ronkonkoma, NY) served as the position sense testing device. Prior to testing, the goniometer was calibrated as part of the regular equipment maintenance schedule for this testing device. When the device is calibrated according to the manufacturer's specifications, the accuracy of the scale is within one standard deviation of the mean values (16).

For the test of active reproduction of passive positioning at 30° of plantar flexion, the test foot was placed on the plantar flexion–dorsiflexion foot plate of the Cybex, according to the manufacturer's instructions for isolating inversion–eversion and plantar flexion–dorsiflexion, and was secured with Velcro straps (Figure 1) (16). For this study, the right ankle served as the testing limb for all six tests since lower extremity proprioception does not appear to be influenced by limb dominance (18, 20). The knee was placed in 90° of flexion and the thigh was stabilized with a Velcro strap. To initiate the test, the foot was placed in the neutral

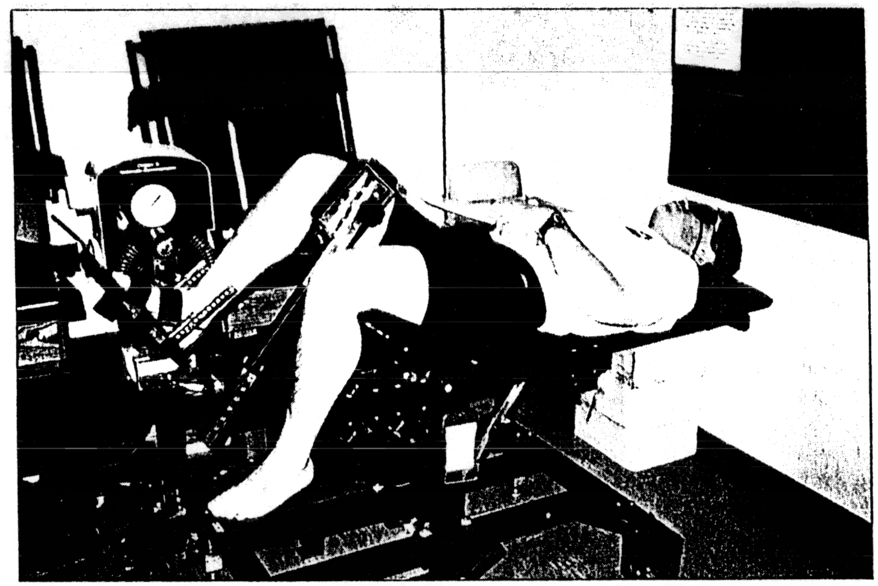

Figure 1 — Test position on the Cybex for assessing active reproduction of passiv positioning at 30° of plantar flexion.

position. Neutral position was easily determined by making sure the vertical arm of the foot plate and the subject's tibial shaft were perpendicular. This position was designated as 0°. In addition, all subjects were blindfolded in an effort to eliminate the contribution of visual cues to joint repositioning.

To familiarize themselves with the testing device, subjects were instructed to actively perform four repetitions of ankle movement ranging from maximal plantar flexion to maximal dorsiflexion. The test began with the tester passively moving the test limb into the test position of 30° of plantar flexion and maintaining that position for 10 s. Following the presentation of the test angle, the subject was asked to actively move the ankle from maximal dorsiflexion to maximal plantar flexion. After completing two full-range movements, the subject was asked to actively reproduce the previously presented test angle of 30° of plantar flexion. Four trials were performed, with the absolute error recorded for each trial. Absolute error was defined as the number of degrees the actively repositioned ankle was away from the original test position. The mean of the four trials for each test condition was calculated to determine an average error score.

Following the same test protocol used for testing at 30° of plantar flexion, the second test of active reproduction of passive positioning was performed at 15° of inversion. For this test, the dynamometer head of the Cybex was adjusted to 55° and the ankle was again secured to the inversion–eversion foot plate. The knee was positioned in 45° of flexion and the thigh was stabilized with Velcro straps (Figure 2). The foot was placed in the neutral position, which for this test was determined by aligning the tibial shaft and the head of the second metatarsal. Neutral position was designated as 0° in order to establish a reference point. Subjects again per-

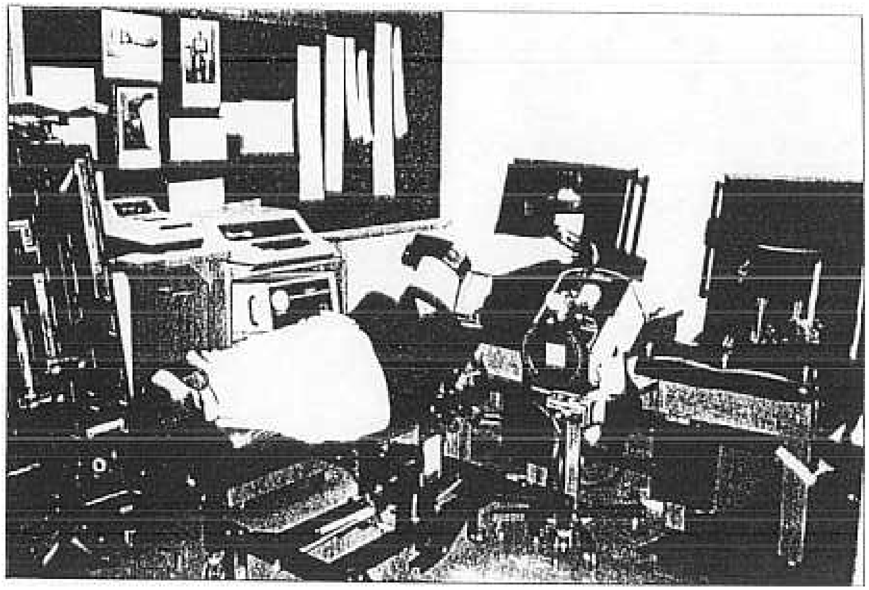

Figure 2 — Test position on the Cybex for assessing active reproduction of passive positioning at 15° of inversion.

formed four active ankle joint movements throughout the maximal range of motion in order to familiarize themselves with the test equipment. To begin the test, the test limb was passively moved into the test position of 15° of inversion and maintained for 10 s. After performing two active movements through the maximal range of motion, the subject was asked to actively reproduce the previously presented test angle of 15° of inversion. Absolute error was recorded for the four trials, with the mean of the four trials calculated to determine an average error score.

Test Conditions

For both tests, the subjects were evaluated during the three test conditions of ankle braced, ankle taped, and an unbraced/untaped control. When joint position sense was tested during the ankle-braced condition, subjects wore a Swede-O-Universal ankle support (Swede-O-Universal, North Branch, MN) applied according to manufacturer's instructions. The primary investigator ensured intersubject consistency by observing the application of the brace and checking for accurate brace fit.

For the ankle-taped test condition, we used a combination of the methods described by Fumich et al. (9) and Wilkerson (27). The athletic tape selected was Coach 1-1/2 in. (Johnson and Johnson Products, Inc., New Brunswick, NJ). An underwrap (Mueller, Prairie Du Sac, WI) was applied to the test ankle before the application of tape. After the pre-wrap was applied, athletic tape was applied with two proximal and one distal circumferential anchoring strips. The remainder of the tape application consisted of applying four stirrups, overlapped by half and anchored with a proximal circumferential strip, four horseshoe strips overlapped by one-half, two alternating figure eights, continuous medial–lateral heel locks, and circumferential strips. To maintain continuity, a certified athletic trainer who had 5 years of taping experience applied all the athletic tape for this study.

Statistical Analysis

The average error of reproduction means and standard deviations were calculated for each test during each test condition (Table 1). Two one-way analyses of variance (ANOVAs) with repeated measures were used to separately analyze the results of the plantar flexion test and the inversion test. To determine significant mean differences between the three conditions, a Scheffé post hoc procedure was performed. All of the data were analyzed using the SPSS® for Windows™ 6.0 version software program (SPSS Inc., Chicago).

Table 1 Degrees of Error in Active Reproduction of Passive Positioning

	Plantar flexion test		Inversion test	
	M	*SD*	*M*	*SD*
Braced condition	4.68[a]	1.52	4.94	1.52
Taped condition	3.90[a]	1.80	4.06[a]	1.41
Control condition	5.93	1.91	5.38	2.12

[a]Indicates significant difference when compared to control condition

Results

Results of the two ANOVAs revealed significant main effects for both the plantar flexion test, $F(2, 50)\ (.95) = 11.20$, $p < .001$, and the inversion test, $F(2, 50)\ (.95) = 5.19$, $p < .05$.

For the plantar flexion test, significant mean differences were revealed between the braced condition and the control condition and between the taped condition ($p < .05$) and the control condition ($p < .05$). The post hoc comparison between the braced and the taped condition was not significantly different.

For the inversion test, a significant mean difference was revealed between the taped condition and the control condition ($p < .05$), but the difference between the braced condition and the control condition was not significant. In addition, there was no significant difference between the braced and the taped condition scores.

Discussion

The results of this study demonstrate that proprioception of the ankle joint is enhanced by the use of a commercially available brace and through the application of athletic tape. When compared to the control condition, the taped condition significantly improved joint position sense for both motions of inversion and plantar flexion, while the braced condition improved joint position sense only for the motion of plantar flexion. This finding may suggest that compared to the control condition, tape may be more effective than a brace in improving ankle joint proprioception. When each test condition is considered separately, there appears to be no difference in the proprioceptive enhancement provided by the brace compared to that provided by the athletic tape.

These improvements in proprioception, demonstrated by enhanced joint position sense, suggest that the application of either an ankle brace or athletic tape is sufficient to stimulate cutaneous nerve receptors and/or mechanoreceptors in the muscles, ligaments, and joint capsule of the ankle joint. Stimulation of the cutaneous nerve receptors and joint mechanoreceptors may result in earlier and enhanced muscular contractions, thus protecting and stabilizing the joint (12). The findings of this study indicate that ankle bracing and/or taping may decrease the severity and incidence of lateral ankle sprains through this mechanism of neural stimulation.

The enhanced ankle joint position sense observed in this study reflects results reported in studies of knee joint proprioception (6, 19). Lephart et al. (19) reported enhanced knee joint kinesthesia following the application of a neoprene knee sleeve, while Barrett et al. (4) found improvements in joint position sense in osteoarthritic and total knee arthroplasty patients who wore an elastic bandage.

The enhanced joint position sensibility observed in this study reflects the effect of the interventions on the afferent neuromuscular pathway. Testing the afferent pathway assesses a subject's ability to perceive joint motion and reproduce joint positions. Stimulating the afferent pathway may improve the efferent neuromuscular response, which may increase the speed and quality of muscle reactions.

The findings of Glick et al. (12) support this assumption. In examining the effects of ankle taping on the efferent neuromuscular pathway, Glick et al. found that the taped unstable ankle demonstrated an earlier onset of peroneal muscle firing and a prolonged peroneal function time during a normal gait cycle compared to the untaped ankle joint. Karlsson and Andreasson (17) also examined the efferent neuromuscular pathway as they compared the effect of tape on the unstable ankle and the stable ankle. Their results demonstrated an increased reaction time in the unstable ankle compared to the stable ankle.

Although the present study failed to reveal a significant improvement in joint position sense for the braced ankle in the inversion reproduction test, bracing may still provide prophylaxis through gains in plantar flexion position awareness. Since the most common mechanism of lateral ankle sprains involves motions of both inversion and plantar flexion, the proprioceptive improvements observed in the present study may increase joint position awareness enough to prevent or lessen the severity of a lateral ankle sprain. However, since we did not combine the motions of plantar flexion and inversion in our test, this suggestion is purely speculative.

Similar to other research studies, this study had limitations that should be considered when interpreting and applying the results. In this study the afferent neuromuscular pathway was assessed by measuring joint position sensibility without evaluating joint kinesthesia. Kinesthesia was not assessed because there is currently no device available for testing ankle joint kinesthesia at the appropriate joint speed.

Conclusions

The results of this study suggest that ankle bracing improves joint position sense in the motion of plantar flexion, while ankle taping improves joint position sense in the motions of plantar flexion and inversion. If ankle injury can be prevented by stimulating proprioceptive mechanisms of the ankle, it appears that bracing and taping are both effective methods for preventing injury. Although bracing was shown to improve joint position sense in the plantar flexion motion test, the hypothesis that this improvement in position sense will provide proprioceptive gains in an inversion with plantar flexion ankle motion is purely speculative. Our results suggest that ankle joint proprioception, quantified by assessing joint position sense, is enhanced by the wearing of an ankle brace and the application of athletic tape.

References

1. Alves, J.W., R.V. Alday, D.L. Ketcham, and G.L. Lentell. A comparison of the passive support provided by various ankle braces. *J. Orthop. Sports Phys. Ther.* 15:10-18, 1992.
2. Barrack, R.L., H.B. Skinner, M.E. Brunet, and R.J. Haddad, Jr. Functional performance of the knee after intraarticular anesthesia. *Am. J. Sports Med.* 11:258-261, 1983.
3. Barrack, R.L., H.B. Skinner, S.D. Cook, and R.J. Haddad, Jr. Effect of articular disease and total knee arthroplasty on knee joint position sense. *J. Neurophysiol.* 50:684-687, 1983.
4. Barrett, D.S., A.G. Cobb, and G. Bentley. Proprioception in normal, osteoarthritic, and replaced knees. *J. Bone Joint Surg. (Br.)* 73:53-56, 1991.
5. Berenberg, R.A., J.M. Shefner, and J.J. Sabol, Jr. Quantitative assessment of position sense at the ankle: A functional approach. *Neurology* 37:89-93, 1987.

6. Bunch, R.P., K. Bednarski, D. Holland, and R. Macinanti. Ankle joint support: A comparison of reusable lace-on braces with taping and wrapping. *Phys. Sportsmed.* 13:59-62, 1985.
7. Burks, R.T., B.G. Bean, R. Marcus, and H.B. Barker. Analysis of athletic performance with prophylactic ankle devices. *Am. J. Sports Med.* 19:104-106, 1991.
8. Firer, P. Effectiveness of taping for the prevention of ankle ligament sprains. *Br. J. Sports Med.* 24:47-50, 1990.
9. Fumich, R.M., A.E. Ellison, G.J. Guerin, and P.D. Grace. The measured effect of taping on combined foot and ankle motion before and after exercise. *Am. J. Sports Med.* 165-170, 1981.
10. Garrick, J.G., and R.K. Requa. The epidemiology of foot and ankle injuries in sports. *Clin. Sports Med.* 7:29-36, 1988.
11. Gehlson, G.M., D. Pearson, and R. Bahamonde. Ankle joint strength, total work, and ROM: A comparison between prophylactic devices. *J. Athletic Training* 26:62-65, 1991.
12. Glick, J.M., R.B. Gordon, and D. Nishimoto. The prevention and treatment of ankle injuries. *Am. J. Sports Med.* 4:136-141, 1976.
13. Greene, T.A., and S.K. Hillman. Comparison of support provided by a semirigid orthosis and adhesive ankle taping before, during, and after exercise. *Am. J. Sports Med.* 11:453-466, 1990.
14. Grigg, P., G.A. Finerman, and L.H. Riley. Joint position sense after total hip replacement. *J. Bone Joint Surg. (Am.)* 55A:1016-1025, 1973.
15. Harter, R.A., L.R. Osternig, and K.M. Singer. Knee joint proprioception following anterior cruciate ligament reconstruction. *J. Sport Rehabil.* 1:103-110, 1992.
16. *Isolated Joint Testing and Exercise—Cybex II Instruction Manual.* Ronkonkoma, NY: Lumex Corporation, Cybex Division, 1983.
17. Karlsson, J., and G.O. Andreasson. The effect of external support in chronic lateral ankle joint instability: An electromyographic study. *Am. J Sports. Med.* 20:257-261, 1992.
18. Lephart, S.M., F.H. Fu, J.J. Irrgang, and P.A. Borsa. Proprioception characteristics of trained and untrained college females [Abstract]. *Med. Sci. Sports Exerc.* 23(4):S113, 1991.
19. Lephart, S.M., M.S. Kocher, F.H. Fu, P.A. Borsa, and C.D. Harner. Proprioception following anterior cruciate ligament reconstruction. *J. Sport Rehabil.* 1:188-196, 1992.
20. Lephart, S.M., J.P. Warner, P.A. Borsa, and F.H. Fu. Proprioception of the shoulder joint in healthy, unstable, and surgically repaired shoulders. *J. Shoulder Elbow Surg.* 3(6):371-380, 1994.
21. Metcalf, G.R., and C.R. Denegar. A critical review of ankle taping. *J. Athletic Training* 18:121-123, 1983.
22. Miller, E.A., and A.C. Hergenroeder. Prophylactic ankle bracing. *Pediatr. Clin. North Am.* 37:1175-1185, 1990.
23. Myburgh, K., C.L. Vaughan, and S.K. Isaacs. The effect of ankle guards and taping on joint motion before, during, and after a squash match. *Am. J. Sports Med.* 12:441-446, 1984.
24. Rovere, G.D., T.J. Clarke, C.S. Yates, and K. Burley. Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. *Am. J. Sports Med.* 16:228-233, 1988.
25. Szczerba, J.E., J.N. Bernier, D.H. Perrin, and B.M. Gansneder. Intertester reliability of active and passive ankle joint position sense testing. *J. Sport Rehabil.* 4:282-291, 1995.
26. Tropp, H., C. Askling, and J. Gillquist. Prevention of ankle sprains. *Am. J. Sports Med.* 13:259-262, 1985.
27. Wilkerson, G.B. Comparative biomechanical effects of the standard method of ankle taping and a method designed to enhance subtalar stability. *Am. J. Sports Med.* 19:588-595, 1991.