Differences in Ankle Range of Motion Before and After Exercise in 2 Tape Conditions

Steven B. Purcell, Brynn E. Schuckman, Carrie L. Docherty, John Schrader and Wendy Poppy

Am J Sports Med 2009 37: 383 originally published online December 16, 2008
DOI: 10.1177/0363546508325925

Differences in Ankle Range of Motion Before and After Exercise in 2 Tape Conditions

Steven B. Purcell,* ATC, Brynn E. Schuckman,* ATC, Carrie L. Docherty,*† PhD, ATC, John Schrader,* HSD, ATC, and Wendy Poppy,‡ PT, ATC
*From the *Department of Kinesiology and the ‡Department of Intercollegiate Athletics, Indiana University, Bloomington, Indiana*

Background: Athletic tape has been used on the ankle to decrease range of motion and to prevent injuries. Results from previous research found that with physical exercise athletic tape loses some of its restricting properties; recently, a new self-adherent taping product was developed that may restrict range of motion regardless of exercise.

Hypothesis: Self-adherent tape will maintain ankle range of motion restriction more than traditional white cloth tape both before and after activity.

Study Design: Controlled laboratory study.

Methods: Twenty volunteers participated in testing procedures on 3 separate days, 1 for each taping condition (self-adherent, white cloth, and no tape). The participant's ankle range of motion was measured with an electrogoniometer before application of the tape, immediately after application of the tape, and after 30 minutes of physical exercise. Range of motion was measured in 2 planes of motion: inversion to eversion and dorsiflexion to plantar flexion.

Results: White cloth tape and self-adherent tape both restricted inversion to eversion range of motion immediately after application, but with 30 minutes of exercise only the self-adherent tape maintained the decreased range of motion. For dorsiflexion to plantar flexion range of motion, the white tape and self-adherent tape both significantly decreased range of motion immediately after application and after the exercise protocol.

Conclusions and Clinical Relevance: The self-adherent tape maintained range of motion restriction both before and after exercise. Conversely, the white cloth tape lost some of its restrictive properties after 30 minutes of exercise.

Keywords: physically active; ankle electrogoniometer; self-adherent tape

Ankle injuries are the most common injury in physically active individuals.[10-12] These injuries often occur in sports requiring frequent cutting and jumping such as basketball, volleyball, and football.[9,12] These activities create an environment that may predispose the ankle to forced inversion and plantar flexion, the common mechanism of injury for most ankle sprains.[11]

Increased incidence of ankle sprains and subsequent lingering disability has led to the realization that prophylactic ankle supports are an important component of injury prevention. Prophylactic measures such as taping and bracing are thought to decrease the incidence of ankle sprains.[13,28] Specifically, incidence of ankle sprains per 1000 exposures decreased from 32.8 to 14.7 when prophylactic ankle taping was employed.[13] It has been hypothesized that ankle taping is effective in reducing ankle injuries because of the increased structural support provided to the ankle mortise by the tape.[1,6] Numerous studies have investigated the effects of taping on range of motion restriction.[7,15,21,23-25] It has been well documented that immediately after tape application, ankle range of motion is restricted in all planes of movement associated with ankle injuries.[14,23,25,27,30] Specifically, inversion and eversion range of motion is reduced immediately after tape application by 37% and 32%, respectively.[7] Not only is the amount of inversion movement reduced, but the rate of movement also decreases immediately after tape application.[1]

Although white cloth tape is frequently used in clinical practice, investigators have identified that white tape loosens with activity and therefore may not provide optimal protection to the joints.[14,15,20,21,24] Some studies have found that tape loses its restrictive properties after just

†Address correspondence to Carrie L. Docherty, PhD, ATC, Smith Research Center, 2805 East Tenth Street, Bloomington, IN 47408 (e-mail: cdochert@indiana.edu).

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 37, No. 2
DOI: 10.1177/0363546508325925

10 minutes of exercise.[15,19-22] This reported loosening may be attributed to the increased extensibility of the ankle connective tissue, perspiration, unevenness of the skin due to muscle contraction, poor skin preparation, or inaccurate tape application.[18,27] Regardless of the reasoning, this reported loosening of white cloth taping may place the athlete at greater risk of ankle injury.

New taping products have been developed to address the inherent drawbacks of white cloth tape. However, limited research has been conducted on these products. One product of interest to clinicians is the newly developed self-adherent tape and prewrap. This type of tape is different than other products because it is self-adhesive and highly moldable. The self-adhesive attributes allow it to adhere to itself but not the skin. This decreases any possible irritation to the skin as there is no mastic in direct contact with the skin surface. Additionally, the self-adhesive prewrap is very different than traditional prewrap because it adds tensile strength to the completed strapping and is water-resistant. Because of the unique characteristics of this type of self-adherent prewrap and tape, we believe it is important to identify how it might maintain stability both before and after exercise. Therefore, the purpose of our study is to evaluate the effectiveness of self-adherent tape and white cloth tape on maintaining ankle range of motion restriction before and after activity.

MATERIALS AND METHODS

Participants

All individuals volunteering to participate in this study were physically active and between the ages of 18 and 30 years. Additionally, they reported no history of ankle fracture, sprain, or strain of the lower leg or ankle within the past 6 months, and no prior surgeries to the ankle or lower extremity. A total of 20 individuals (11 women and 9 men; average age, 19.8 ± 1.7 years; height, 171.3 ± 11.4 cm; weight, 68.1 ± 8.8 kg) volunteered to participate in the study. Participants were recruited from a large Division I university population and residents of a midwestern city. Individuals were excluded from the study if they reported an allergy to any adhesive material. The dominant ankle was used for all testing procedures. Dominance was determined by asking the individual which foot he or she used to kick a ball.[8] The Indiana University Institutional Review Board for the Protection of Human Subjects approved the study and an informed consent document was signed before participation in the study.

Procedures

Participants reported to the research laboratory on 3 different occasions, 1 day for each tape condition. The tape conditions were no tape, white cloth tape (Zonas, Johnson & Johnson Consumer Products, Bridgewater, New Jersey) with prewrap (Mueller, Johnson & Johnson), and self-adherent tape (PowerTape, Andover Healthcare Inc, Salisbury, Massachusetts) with self-adherent prewrap (PowerFlex, Andover). Both the white and self-adherent tapes were 1.5 in wide. The order of tape condition was counterbalanced for all participants. This ensured that a third of the participants performed the no tape condition first, a third performed the white cloth tape first, and a third performed the self-adherent tape condition first.

For the white cloth tape and self-adherent tape conditions, the dominant limb of each participant was clean, dry, and unshaven. Two heel and lace antifriction pads with a small amount of skin lubricant were placed over the Achilles tendon and anterior ankle joint.

For the white cloth tape condition, participants were sprayed with an adhesive spray (Cramer Tuff-skin, Cramer Products Inc, Gardner, Kansas) over the foot and lower leg, allowing it to dry for approximately 5 seconds. Prewrap was then applied from the midfoot to the base of the calf in a circular pattern. The application of white cloth tape included 2 anchor strips at the base of the calf, 3 stirrups applied medial to lateral, circular strips applied from the 2 anchors to the malleolus, 2 separate heel locks (1 medially and 1 laterally), a figure-of-8 strip, and finally 2 anchor strips at the base of the lower leg. The complete technique is shown in Figure 1.

The self-adherent tape condition started with the self-adherent prewrap applied from the midcalf in a continuous circular motion to the midfoot, incorporating 2 heel locks around the ankle joint. Subsequently, the self-adherent prewrap was compressed by direct hand pressure. The self-adherent tape was then applied in a similar manner as the white tape condition with 1 exception—for the self-adhesive tape condition, the heel lock and figure-of-8 strips alternated. The self-adherent tape was also manually compressed distal to proximal. Compression was recommended by the manufacturer of this product to increase conformity to the joint. The complete technique is shown in Figure 2.

All taping procedures were completed by the same clinician. For both tape applications, the tape was applied directly over the prewrap and not anchored to the skin. As noted, both tape applications were similar in that they both included anchor strips, stirrups, circular straps, heel locks, and figure-of-8 strips. The slight modifications were simply made to ensure that the research followed standard protocols used in the clinical setting.

Range of Motion Testing

Range of motion was measured in 2 directions: inversion to eversion range and plantar flexion to dorsiflexion range. For each day of testing, ankle range of motion was measured 3 times: baseline (before the tape was applied), pretest (immediately after the tape was applied), and posttest (after 30 minutes of exercise). For the no tape condition, the participant sat quietly for 5 minutes between the baseline and pretest range of motion measurements.

Each participant's ankle range of motion was measured using an ankle electrogoniometer (Figure 3). This device has been used in previous research evaluating ankle range of motion,[4,5] and specifications are detailed in an article by Myburgh et al.[23] Before data collection, test-retest reliability testing was conducted. We used the ankle electrogoniometer to test ankle inversion-eversion and

Figure 1. White cloth tape condition: a, prewrap; b, 3 stirrups; c, medial heel lock; d, lateral heel lock; e, figure-of-8; and f, completed.

dorsiflexion–plantar flexion range of motion on 2 separate days. The intraclass correlation coefficient (ICC) formula (2,k) was used to evaluate the data. For inversion-eversion range, the ICC was 0.87 (standard error of the mean [SEM] = 2.51°) and for dorsiflexion–plantar flexion range the ICC was 0.99 (SEM = 1.41°)

For the testing procedures, participants were seated with the knee extended and the lower leg secured in the ankle electrogoniometer. The limb was fixed in place with Velcro straps around the calf just above the malleoli and across the distal portion of the foot. The upper leg of the dominant limb was secured to the table with Velcro straps to restrict any hip or knee rotation. The ankle was positioned in subtalar neutral using the congruency method,[17] and the goniometer was set to 0. For each direction, the participant was instructed to actively move the joint to the extreme range of motion. Range of motion was recorded to the nearest 0.1°. Two practice trials followed by 3 test trials were conducted in each direction and the mean was used for statistical analysis.

Figure 2. Self-adherent tape condition: a, self-adherent prewrap applied; b, 3 stirrups; c, lateral heel lock; d, figure-of-8; e, medial heel locks; and f, completed.

Exercise Protocol

After baseline and pretest range of motion was measured, each participant performed an exercise routine. The researcher first demonstrated the 8-station exercise routine and then asked the participant to demonstrate each station during the 5-minute warm-up. The exercise routine included the following drills: lateral shuffles, forward/backward running, agility ladder, figure-of-8, 90° cuts with lateral shuffle, wall jumps, forward jogging while jumping over cones, and zigzags. The participant continuously repeated the stations for 20 minutes. Participants were instructed to exercise at a moderate level; this was monitored by asking them to report their level of intensity using a rated perceived exertion scale.[2] All participants reported an exertion level between 3 and 5 on all test days. These numeric values

TABLE 1
Means and Standard Deviations for Inversion-Eversion Range of Motion (in Degrees)

	Baseline	Pretest	Posttest
No tape	31.49 ± 8.83	32.23 ± 9.53	31.03 ± 8.92
White cloth tape	32.01 ± 8.79	27.77 ± 9.87[a]	31.82 ± 10.80
Self-adherent tape	30.00 ± 8.16	22.66 ± 7.83[ab]	25.76 ± 9.68[ab]

[a]Significantly different from no tape ($P < .05$).
[b]Significantly different from white cloth tape ($P < .05$).

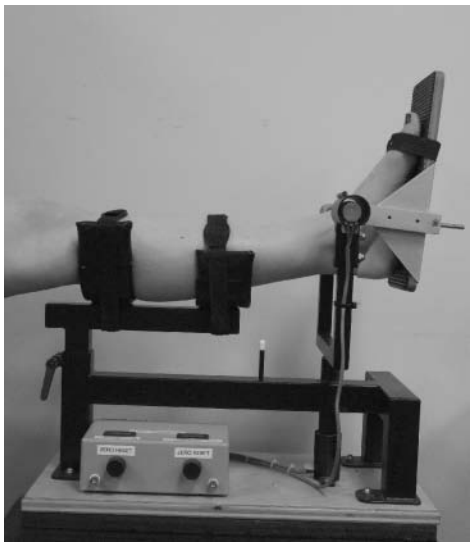

Figure 3. Ankle electrogoniometer.

represented moderate to strong (heavy) exertion on the Borg CR10 scale.[2] The number of exercise circuits completed in the 20-minute period was recorded to ensure that the participants were exercising with a constant intensity for all 3 days of testing. The average number of exercise circuits the participants completed in the 20-minute period was 12.09 (standard deviation = 1.3). Participants completed the exercise circuit with a 5-minute walk to cool down.

Directly after the participants finished the cool-down walk, ankle range of motion was measured according to the aforementioned protocol. The entire procedure was repeated 2 more days, approximately 24 to 72 hours apart, for the other 2 taping conditions.

Statistical Analysis

Two separate repeated-measures analyses of variance (RMANOVAs) were performed to determine differences between the tape conditions, 1 for the inversion to eversion range of motion and 1 for the dorsiflexion to plantar flexion range of motion. For each RMANOVA, 2 within-condition factors were included: time at 3 levels (baseline, pretest, posttest) and tape at 3 levels (no tape, white cloth tape, self-adherent tape). Tukey post hoc analysis was performed on any significant findings. The alpha level was set at $P < .05$.

TABLE 2
Means and Standard Deviations for Dorsiflexion–Plantar Flexion Range of Motion (in Degrees)

	Baseline	Pretest	Posttest
No tape	70.14 ± 12.54	68.07 ± 11.21	67.44 ± 12.77
White cloth tape	68.37 ± 12.51	56.04 ± 13.77[a]	60.73 ± 13.62[a]
Self-adherent tape	67.84 ± 12.77	51.05 ± 12.50[ab]	57.74 ± 12.52[a]

[a]Significantly different from no tape ($P < .05$).
[b]Significantly different from white cloth tape ($P < .05$).

RESULTS

Means and standard deviations for the ankle range of motions for the 3 tape conditions are provided in Tables 1 and 2. Repeated-measures analysis of variance revealed a significant interaction between tape condition and time for inversion to eversion range of motion ($F_{4,76} = 10.88$; $P < .001$) and dorsiflexion to plantar flexion range of motion ($F_{4,76} = 14.35$; $P < .001$).

Inversion to Eversion Range

Results of the Tukey post hoc analysis revealed that during the white tape condition, inversion to eversion range of motion was restricted immediately after application ($P < .05$) but not after the exercise protocol ($P > .05$). Conversely, during the self-adherent tape condition, inversion to eversion range of motion was significantly restricted immediately after application ($P < .05$) and after the exercise protocol ($P < .05$). When directly comparing the 2 types of tape, we identified a significant difference between the 2 tape conditions immediately after application ($P < .05$) and after the exercise protocol ($P < .05$). At both time periods, the self-adherent tape condition provided a greater reduction in range of motion. No significant difference was noted between baseline, pretest, and posttest in the no tape condition ($P > .05$).

Dorsiflexion to Plantar Flexion Range

Results of the Tukey post hoc analysis revealed that during both the white tape and self-adherent tape conditions, dorsiflexion to plantar flexion range of motion was significantly restricted immediately after application ($P < .05$) and after the exercise protocol ($P < .05$). When directly comparing the 2 types of tape, we identified a significant difference between the 2 tape conditions immediately after application ($P < .05$). The self-adherent tape restricted range of motion to a greater extent than the white tape. However, after exercise, we found no significant difference between the tape conditions. No significant difference was found between baseline, pretest, and posttest in the no tape condition ($P > .05$).

DISCUSSION

The ultimate objective of prophylactic ankle taping is to reduce the incidence and significance of injury by restricting excessive ranges of motion. Many researchers have recommended that using white cloth tape may be valuable in providing ligamentous protection[16,25,27,29]; however, the potential loosening of the white tape after exercise continues to be a troublesome issue for many clinicians. Self-adherent tape and prewrap are relatively new products and little to no previous research has been conducted on them. Interpretation of these results allows us to conclude that after exercise, the self-adherent tape application restricts inversion to eversion range of motion to a greater degree than either the white cloth tape condition or the no tape condition. For dorsiflexion to plantar flexion range of motion, both white cloth tape and self-adherent tape applications restricted range of motion before and after exercise.

Inversion to Eversion Range of Motion

The majority of studies agree with our findings that white cloth tape restricts ankle range of motion immediately after tape application.[7,15,16,21-24] Similarly, the self-adherent tape application also restricts range of motion immediately after application. The difference between the 2 tape conditions becomes apparent when range of motion is measured after physical activity.

During athletic events, there is a significant demand at the ankle, stressing the lateral structures. This lateral stress also places stress on the ankle strapping and possibly increases the inversion to eversion range of motion. This repeated side-to-side motion may eventually loosen the tape, allowing greater inversion to eversion range of motion and therefore nullifying its stabilizing effect. Previous investigations have reported that white cloth tape loses some of the inversion to eversion ankle range of motion restriction after exercise but may still possess stabilizing characteristics.[7,16,29] However, our study found that white cloth tape lost 99% of its support in the inversion to eversion direction after 30 minutes of exercise. Therefore, the posttest measurements approached the same values for inversion to eversion as the baseline range of motion measurements. Thus we can conclude that the supporting qualities of white cloth tape were unable to maintain frontal plane ankle joint stability following 30 minutes of exercise.

We found that after exercise, the self-adherent tape maintained its restriction of inversion to eversion ankle range of motion. This is contrary to the findings of the white cloth tape condition. After exercise, white cloth tape returned to the baseline range of motion measures, while the self-adherent tape condition maintained more than 50% of its original restrictive properties. These findings suggest that the self-adherent tape maintained frontal plane range of motion restriction better than white cloth tape after 30 minutes of exercise.

Several potential explanations exist for the significant range of motion restriction when using the self-adherent products with exercise. The first is the use of self-adherent prewrap underneath the self-adherent tape. The manufacturer purports that self-adherent prewrap by itself possesses up to 23 lb of tensile strength. Therefore, self-adherent prewrap alone provides increased stability to the ankle joint. It is important to clarify that information on tensile strength was provided by the manufacturer and has not been independently validated. However, it does provide a compelling justification for the maintenance of ankle joint stability during exercise. Traditional prewrap used under adhesive tape applications has no tensile strength and is applied purely as a friction reducer and skin protector. A second explanation for the sustained stabilization with the self-adherent products may be due to the sweat-resistant capabilities of both the self-adherent tape and prewrap. Perspiration with exercise has been hypothesized as one of the main reasons white cloth tape loses its restrictive properties.[18] Larsen[18] reported that a traditional taping technique using white cloth tape functioned merely as a "canvas boot" because of perspiration during physical activity. The self-adherent tape and prewrap are sweat-resistant and therefore may maintain structural integrity and provide stability to the ankle during physical activity. Finally, minimal stretch allowed by the self-adherent tape could be a potential explanation for the maintained joint stability. The manufacturers report that self-adherent tape contains less than 1% stretch. Therefore, the self-adherent tape does not elongate with activity. This is in contrast to cloth athletic tape, which has approximately 7% stretch at failure.[3]

Dorsiflexion to Plantar Flexion Range of Motion

Many researchers have stated that dorsiflexion and plantar flexion range of motion decrease immediately after tape application.[7,21-24,29] Our findings suggest that immediately after tape application, both the white cloth tape and the self-adherent tape restrict dorsiflexion to plantar flexion range of motion. Additionally, after 30 minutes of exercise, both tape applications maintained approximately 65% of the original restrictive properties in the sagittal plane. Therefore, both tape conditions were successful in restricting the amount of dorsiflexion to plantar flexion range of motion immediately after application and after 30 minutes of exercise.

Limitations

The closed basket-weave technique used in our study is a standard technique for basic or preventive ankle protection. Furthermore, it is the most common technique used in previous research studies.[1,26] However, there may be as many variations in taping procedures as there are clinicians. Consequently, the results of this study can only be generalized to utilization of the closed basket-weave technique.

In our current research, we did not require participants to be clean-shaven. This was done to provide standardization between tape conditions. The primary rationale for this decision was clinical practice. Some clinicians require the leg to

be shaven when using white cloth tape, while others do not; additionally, the manufacturers of self-adherent prewrap do not suggest having participants shave their legs. Therefore, the best way to provide a standardized approach to each taping condition and still follow appropriate clinical guidelines was to not require the participants to shave.

Future Research

Future research is needed to investigate the mechanical properties of the self-adherent tape. Components such as tensile strength and stretch capabilities need to be investigated by an independent agency. Additionally, the merits of self-adherent tape should be compared with various ankle braces before and after exercise. With exercise, braces can be tightened to help maintain the decreased range of motion. Therefore, the posttest range of motion with bracing may be similar to the self-adherent tape condition investigated in this study.

Clinical Implications

The use of self-adherent taping products appears to be effective when taping the ankle for physical activity. The self-adherent tape restricted range of motion both before and after exercise and therefore could assist in preventing the incidence and/or severity of ankle injury. Even with perspiration in the lower leg with physical activity, the self-adherent products appear to maintain good ankle stabilization.

In conclusion, both the white cloth tape condition and the self-adherent tape condition provided dorsiflexion to plantar flexion range of motion restriction before and after exercise. Conversely, both tape conditions restricted inversion to eversion ankle range of motion immediately after application, but after 30 minutes of exercise, only the self-adherent tape sustained the decreased range of motion. This decreased ankle range of motion provided by the self-adherent tape allows the ankle to maintain a more neutral position, thereby reducing stresses placed on the ankle joints, and ultimately assisting in reducing the chance of injury.

REFERENCES

1. Alt W, Lohrer H, Gollhofer A. Functional properties of adhesive ankle taping: neuromuscular and mechanical effects before and after exercise. *Foot Ankle Int.* 1999;20:238-245.
2. Borg G. The Borg CR10 Scale. In: *Borg's Perceived Exertion and Pain Scales.* Champaign, IL: Human Kinetics; 1998:39-43.
3. Bragg RW, Macmahon JM, Overom EK, et al. Failure and fatigue characteristics of adhesive athletic trape. *Med Sci Sport Exerc.* 2002;34:403-410.
4. Docherty CL, Arnold BL, Zinder SM, Gansender BM. Relationship between two proprioceptive measures and stiffness at the ankle. *J Electromyogr Kinesiol.* 2002;14:317-324.
5. Docherty CL, Moore JH, Arnold BL. Effects of strength training on strength development and joint position sense in functionally unstable ankles. *J Athl Train.* 1998;33:310-314.
6. Firer P. Effectiveness of taping for the prevention of ankle ligament sprains. *Br J Sports Med.* 1990;24:47-50.
7. Fumich RM, Ellison AE, Guerin GJ, Grace PD. The measured effect of taping on combined foot and ankle motion before and after exercise. *Am J Sports Med.* 1981;9:165-169.
8. Gabbard C, Hart S. A question of foot dominance. *J Gen Psychol.* 1996;123:289-298.
9. Garrick JG. Epidemiologic perspective. *Clin Sports Med.* 1982;1: 13-18.
10. Garrick JG. Epidemiology of foot and ankle injuries. *Med Sport Sci.* 1987;23:991-997.
11. Garrick JG. The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *Am J Sports Med.* 1977;5:241-242.
12. Garrick JG, Requa RK. The epidemiology of foot and ankle injuries in sports. *Clin Podiatr Med Surg.* 1989;6:629-637.
13. Garrick JG, Requa RK. Role of external support in the prevention of ankle sprains. *Med Sci Sports Exerc.* 1973;5:200-203.
14. Greene TA, Hillman SK. Comparison of support provided by a semirigid orthosis and adhesive ankle taping before, during, and after exercise. *Am J Sports Med.* 1990;18:498-506.
15. Gross MT, Bradshaw M, Ventry L, Weller K. Comparison of support provided by ankle taping and semirigid orthosis. *J Orthop Sports Phys Ther.* 1987;9:33-39.
16. Gross MT, Lapp A, Davis J. Comparison of Swede-O-Universal® ankle support and Aircast® circled Sport-Stirrup™ orthoses and ankle tape in restricting eversion-inversion before and after exercise. *J Orthop Sports Phys Ther.* 1991;13:11-19.
17. James SL, Bates BT, Osternig LR. Injuries in runners. *Am J Sports Med.* 1978;6:40-50.
18. Larsen E. Taping the ankle for chronic instability. *Acta Orthop Scand.* 1984;55:551-553.
19. Man IO, Glover K, Nixon P, Poyton R, Terre R, Morrissey M. Effect of body position on foot and ankle volume in healthy subjects. *Clin Physiol Funct Imaging.* 2004;24:323-326.
20. Manfroy PP, Ashton-Miller JA, Wojtys EM. The effect of exercise, prewrap, and athletic tape on the maximal active passive ankle resistance to ankle inversion. *Am J Sports Med.* 1997;25:156-163.
21. Metcalfe RC, Schlabach GA, Looney MA, Renehan EJ. A comparison of moleskin tape, linen tape, and lace-up brace on joint restriction and movement performance. *J Athl Train* 1997;32:136-140.
22. Morris H, Musnicki W. The effect of taping on ankle mobility following moderate exercise. *J Sports Med Phys Fitness.* 1983;23:422-426.
23. Myburgh KH, Vaughan CL, Isaacs SK. The effect of ankle guards and taping on joint motion before, during, and after a squash match. *Am J Sports Med.* 1984;12:441-446.
24. Paris D, Kokkaliaris J, Vardaxis V. Ankle ranges of motion during extended activity periods while taped and braced. *J Athl Train.* 1995;30:223-228.
25. Pederson T, Ricard M, Merrill G, Schulthies S, Allssen P. The effects of spatting and ankle taping on inversion before and after exercise. *J Athl Train.* 1997;32:29-33.
26. Rarick G, Bigley G, Karst R, Malina RM. The measurable support of the ankle joint by conventional methods of taping. *J Bone Joint Surg Am.* 1962;44:1183-1190.
27. Ricard M, Sherwood SM, Schulthies SS, Knight KL. Effects of tape and exercise on dynamic ankle inversion. *J Athl Train.* 2000;35: 31-37.
28. Rovere GD, Clarke TJ, Yates CS, Burley K. Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. *Am J Sports Med.* 1988;16:228-232.
29. Seitz C, Goldfuss AJ. The effect of taping and exercise on passive foot inversion and ankle plantarflexion. *J Athl Train.* 1984;19:178-182.
30. Wilkerson GB. Comparative biomechanical effects of the standard method of ankle taping and a taping method designed to enhance subtalar stability. *Am J Sports Med.* 1991;19:588-595.