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The Effects of Ankle Taping and a Lace-up Ankle Brace on Balance Control while Initiating Gait

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Abstract. [Purpose] The purpose of this study was to examine the center of pressure (COP) trajectory variables while initiating gait under three different ankle support conditions: no external ankle support, ankle taping, and the use of a lace-up ankle brace. [Subjects] The study subjects were 7 healthy males (mean [SD] age, 22.4 [1.5]; range, 22–25 years) and 8 healthy females (mean [SD] age, 22.8 [0.8]; range, 22–24 years). [Methods] Subjects stood in a predetermined position on the floor in front of a force platform and then initiated gait on the force platform at a self-paced speed under the conditions of no external ankle support, ankle taping, and lace-up ankle brace. Changes in the COP trajectories were compared among the three test conditions using one-way repeated analysis of variance. [Results] The ankle external support devices, ankle taping and the lace-up ankle brace, significantly decreased the COP displacement in the mediolateral direction as compared to the no external support condition. However, there were no significant differences in the COP displacement in the anteroposterior direction, the average COP velocity, and the total length of the COP path among the three test conditions. [Conclusion] Intervention using a prophylactic ankle support device appears to be an effective means of reducing injuries because it provides increased mechanical stability.
Key words: Prophylactic ankle support, Center of pressure, Balance

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INTRODUCTION

Ankle sprains are considered to be the most commonly reported sports injury. They account for 19–23% of all sports injuries[1–3)] and in the United States more than 25,000 ankle sprains occur every day[4)]. Injuries of the anterior talofibular ligament are the most common followed by calcaneofibular ligament injuries, and in total they account for 90–95 % of ankle sprains[5,6)]. Occasionally, the posterior talofibular ligament is also injured[7)]. Inversion and/or internal rotational force at the ankle joint when the ankle is in plantar flexion are the most common causes of the ankle sprain injury[8)]. Although the initial injury resolves with complete recovery, some people may suffer recurrence of ankle sprain, resulting in moderation or discontinuation of sport activities. Twenty to fifty percent of people with an ankle sprain suffer symptoms such as pain, inflammation, and limited motion related to residual disability[9,10)].

Certain competitive sports such as soccer, American football, basketball, and field hockey have been reported to have high incidences of ankle sprains. For athletes playing these sports, ankle sprains are a pervasive problem[9,11–13)]. A high incidence of ankle sprain among athletes who play in sports in combination with residual post-strain disability has led to the development of preventive measures. Among these measures use of prophylactic ankle measures is common among players of sports either as a means of preventing ankle injuries or as a rehabilitation strategy. Numerous studies[14–21)] have investigated the effectiveness of ankle taping and braces, with findings generally supporting the role of strapping and bracing in reducing the incidence of ankle sprain injuries. For example, the incidence rate of ankle sprains among braced soccer players was reported as 3% as compared with 11% among unbraced soccer players[12)]. Similarly, among basketball players, the incidence of ankle sprain injury among those who were braced was reported to be 1.6 per 1,000 games compared with 5.2 per 1,000 games among those who were not braced[22)]. Garrick and Requa[23)] have also reported that among basketball players the incidence of the ankle sprain was 6.5 per 1,000 games among those who were taped as compared with 30.4 per 1,000 games among those who were not taped. In addition, ankle bracing can significantly reduce the incidence and severity of recurrence of ankle sprain[24)].

Several mechanisms have been suggested for the reduction of ankle sprain by application of an ankle external support. It is thought that ankle external supports such as prophylactic taping or a laced brace increase mechanical stability thereby reducing the incidence of ankle sprain[25]. Previous studies have reported that prophylactic ankle taping and laced ankle braces significantly limit ankle range of motion as compared with the range of motion of an untaped or unbraced ankle, but the stabilizing effect of ankle taping is rapidly diminished by approximately 21% after only short bouts of exercise[26–28]. In addition, ankle external supports may reduce the risk of ankle sprain through enhanced foot position awareness (proprioception to the ankle)[29]. This phenomenon is believed to involve facilitation of dynamic neuromuscular protective mechanisms via cutaneous sensory stimulation of plantar surface position and orientation[30], which is provided by traction of tape either on hairy skin of the leg and foot, or plantar skin when uniting the skin of the foot with the leg with ankle taping[29]. Furthermore, ankle taping enhances the activation of peroneal muscles at the ankle, which is essential for counteracting a potentially injurious inversion force after landing[31].

Together, these findings suggest that increased afferent feedback from enhanced ankle joint position sense, due to the stimulation of the cutaneous receptors in the foot and shank by ankle taping or lace-up brace, positively influence the ability of individuals to control balance during walking[32,33]. Extrinsic ankle supports limit ankle range of motion and that may lessen the efficiency of the ankle strategy used to maintain postural control[34,35]. The collective observations indicate that external ankle support may influence postural control positively or negatively. Foot position awareness of the plantar surface and ankle joint position sense are important sensory inputs for maintaining postural control[36]. Maintenance of postural control is diminished in those who are susceptible to ankle injury as compared to those with greater postural control[37].

These previously reported studies clearly indicate the importance of understanding how external ankle support influences postural control. Research on ankle external supports, however, has focused mostly on the mechanical support offered by ankle taping or the lace-up type of ankle brace. Little is known about the effects of ankle taping and a lace-up ankle brace on selected postural control variables such as the center of pressure (COP) trajectories. Investigating the changes in COP trajectory variables would provide important information for understanding how individuals modulate the gait pattern while walking[38,39] since COP represents the response of the central nervous system to movement of the whole body center of mass[40]. Thus, the purpose of this study was to examine the COP trajectory variables while initiating gait under three different ankle support conditions: no ankle external support, ankle taping, and lace-up ankle brace.

SUBJECTS AND METHODS

The study subjects were seven healthy males (mean [SD] age, 22.4 [1.5]; range, 22–25 years) and eight healthy females (mean [SD] age, 22.8 [0.8]; range, 22–24 years) with no known neurological or orthopedic impairments. None of the subjects had an history of ankle injury within the last 5 years.

Table 1. Subject characteristics

Group	N	Age	Height	Weight
Male	7	22.4 (1.5)	175.2 (6.3)	71 (4.6)
Female	8	22.8 (0.8)	161.5 (5.2)	51.4 (2.6)

Note: Values are means ± SD (standard deviations).

All participants signed an informed consent form prior to participation. Subjects' characteristics are summarized in Table 1.

For ankle taping 3.8 cm-wide athletic adhesive tape (Johnson and Johnson, New Brunswick, NJ, USA), heel and lace antifriction pads (Mueller Sports Medicine, Prairie du Sac, WI, USA), skin lubricant (Cramer Products, Gardner, KS, USA), and tape adherent spray (Mueller Sports Medicine) were used. A combination of the Gibney closed basketweave and continuous figure-8 heel locks as shown by Rarick et al.[41] were used for the taping technique. The skin was shaved and cleaned, and a tape adherent was evenly sprayed over the skin to be taped to minimize slippage. The adherent was allowed to dry for a few seconds prior to applying the tape underwrap or heel lace pads. Antifriction heel and lace pads lubricated with a petroleum jelly lubricant and a thin layer of underwrap were then applied over the Achilles and pretibial tendons before applying nonelastic adhesive athletic tape. This technique is commonly used in the taping of athletes. Proximal and distal anchor strips were attached to the skin at the musculotendinous junction of the gastrocnemius and Achilles tendon. Two extra anchor strips of tape were applied over the tarsal arch of the foot to afford the rear foot more support in valgus. Following the anchor application, the tape was applied in a basketweave followed by heel locks and figure of eights. Three vertical U-shaped tape strips (stirrups) and three horizontal U-shaped tape strips (horseshoes) were applied. Two continuous figure-8 heel locks were then applied under the foot, behind the heels, and around the lower leg. Both ankles were taped by the same certified athletic trainer to control taping variations between individuals. The ankle brace used was the Swede-O-Universal® lace-up ankle stabilizer (Swede-O-Universal, North Branch, MN, USA). Each subject put on a brace appropriate for their shoe size following the instructions of the manufacturer. A certified athletic trainer supervised the subject's application of the brace to ensure a proper fit.

A force platform (AMTI, Newton, MA, USA), embedded in a level walkway (5 m in length and 1.22 m in width), measured three components of the ground reaction force (GRF) at the initiation of gait. Amplified force platform signals were sampled on-line at a rate of 1,000 Hz for 10 seconds. COP was defined as the point of application of the GRF vector on the force platform and was analyzed using BioAnalysis v2.0 software (AMTI). For each trial, subjects stood in a predetermined position on the floor in front of the force platform. Subjects then initiated gait on the force platform at a self-paced speed with the right limb in response to auditory cues. Subjects completed two practice

Table 2. Mean values (± SD) of the COP parameters (cm) and COP velocity (cm/sec) of right foot.

Dependent variables	No external ankle support	Lace-up ankle brace	Ankle taping
M-L displacement*	4.95 (0.2) +#	4.31 (0.2) +¶	3.56 (0.2) #¶
A-P displacement	21.05 (0.39)	20.56 (0.39)	21.19 (0.39)
COP velocity	57 (4.63)	56.42 (4.25)	56.61 (4.51)
COPL	44.99 (5.33)	46.71 (3.3)	44.76 (3.33)

*Significant main effect for the external ankle support condition (p<0.01). +Significant difference between no external ankle support and lace-up ankle brace (p<0.01). #Significant difference between no external ankle support and ankle taping (p<0.01). ¶Significant difference between lace-up ankle brace and ankle taping (p<0.01).
SD: Standard deviation; M-L: mediolateral; A-P: anteroposterior; COP: center of pressure; COP velocity: average velocity of the center of pressure; COPL: total length of the center of pressure path.

trials and approximately five successful experimental trials. Each subject performed initiation of gait under the three test conditions: (a) no ankle external support, (b) adhesive ankle taping, and (c) lace-up ankle brace. The order in which subjects wore ankle support was counterbalanced to minimize learning effects.

One-way repeated analysis of variance (ANOVA) was used to determine whether there were any significant differences among the experimental conditions. Single degree of freedom mean contrasts were used to determine the source of any significant effects. In this case the independent variable was ankle external support (no external support, taping, lace-up brace). Statistical significance was indicated at $p<0.05$ and $p<0.01$. The dependent variables were anteroposterior (A-P) and mediolateral (M-L) displacement of COP, average velocity of COP, and the total length of COP path.

The A-P (or M-L) displacement of COP was defined as the total distance (or difference) between the minimum and maximum A-P (or M-L) COP location for the length of time that the right foot was in contact with the force platform. The average velocity of the COP was defined as the path length of COP divided by the length of time that the right foot was in contact with the force platform. The total length of the COP path was defined as the total path traveled by the COP in the length of time that the right foot was in contact with the force platform. SPSS 14.0 KO statistical software (SPSS, Chicago, IL, USA) was used for the statistical analyses.

RESULTS

All subjects enrolled in the study completed the experimental trials and were included in the data analysis. Comparisons of the COP data between no ankle external support, ankle taping, and lace-up ankle brace were made for the A-P and M-L displacement of COP, the average velocity of COP, and the total length of the COP path. There was a significant main effect for the M-L displacement of COP ($p<0.01$) (Table 2). The mean values of the M-L displacement of COP for both ankle taping and lace-up ankle brace were both significantly lower ($p<0.01$) than that for no ankle external support condition. Furthermore, the mean value of the M-L displacement of COP for ankle taping was significantly lower than that for lace-up ankle brace ($p<0.01$). The mean values of the M-L displacement of the COP for the adhesive ankle taping and the lace-up ankle brace were 72% and 87% lower than the mean M-L displacement of the COP for no external ankle support. In addition, the mean value of the M-L displacement of the COP for the adhesive ankle taping condition was 83% lower than the mean M-L displacement of COP for the lace-up ankle brace condition. However, the mean values for the A-P COP displacement, the average velocity of COP, and the total length of the COP path were similar for all the conditions with no significant differences ($p>0.05$). Table 2 presents details of the mean values of the COP data for the participants.

DISCUSSION

No previous studies have examined the COP trajectory variables under three different external ankle support conditions while initiating gait. This study provides preliminary information about the effects of ankle taping and bracing on balance control. The results demonstrate that ankle external support devices such as ankle taping and lace-up ankle brace significantly decrease the COP displacement in the M-L direction as compared to no ankle external support, without any significant change in the COP displacement in the A-P direction, the average velocity of COP, and the total length of the COP path.

The finding of decreased COP displacement in the M-L direction during external ankle support is comparable a previous finding that M-L postural sway was reduced when normal subjects performed a single leg stance with a semi-rigid, stirrup-type brace[42)]. Those subjects showed increased postural control, which was manifested as a decrease in the amplitude of postural sway when compared to the no ankle external support condition. In contrast to the present study, this former study examined the postural sway during unilateral stance instead of measuring the COP trajectory variables during gait initiation that are more dynamic than static postural control tests. The cause of the improvement may have been due to the fact that the ankle external support device enhanced proprioception from cutaneous receptors at the ankle joint, thus improving the accuracy of active replication of reference ankle position[43)]. Other previous studies have also reported improved joint position sense with direct application of ankle tape strap to the skin in a nonweight-bearing position of plantar flexion position[44)] as well as improved ability of subjects to reproduce a plantar flexion joint angle with application of ankle taping or a lace-up ankle brace[45].

No differences were noted in the COP trajectory variables of displacement in the A-P direction, average velocity, and total path length among the three ankle support conditions in the present study. Interpreting no significant change among the ankle support conditions for these COP trajectory variables is difficult as no previous study has investigated the effects of ankle external support on these variables while initiating gait. Measurement of postural control variables such as COP trajectories is one method of examining proprioception at the ankle, since proprioception is one of inputs to the three primary sensory systems (somatosensory, visual, and vestibular) involved in maintaining balance. In the present study, the effect of ankle taping and/or bracing did not seem to be strong enough to change the COP trajectory variables of A-P displacement, the average velocity, and total path length. The reason that there was no change in these variables is not entirely clear, but it may be hypothesized that restriction of the range of ankle motion, to prevent excessive frontal-plane motion for sprain prevention, primarily influenced the COP trajectory in the M-L direction when wearing the ankle tape or brace[43].

This had several limitations. First, there was a relatively small sample of subjects. Second, only two types of external ankle support were employed for testing, limiting results to ankle taping and lace-up ankle brace. Furthermore, the current study sample consisted of a sample of uninjured subjects; thus, the findings from this study can be compared only with a similar group of subjects.

In conclusion, the findings of the present study reveal that a prophylactic ankle support device decreases COP displacement in the M-L direction only when initiating gait, which indicates a positive influence on dynamic balance control, but not COP displacement in the A-P direction, average velocity of COP, or total length of COP path. The findings of this study indicate that intervention using a prophylactic ankle support device is an effective means of reducing injuries through provision of increased mechanical stability. Further research using a well-designed, randomized, controlled trial using a larger subject population and various types of ankle external support devices is warranted to determine whether prophylactic ankle support devices are an effective way of preventing ankle sprains.

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