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The Effects of Ankle Braces on Lower Extremity Electromyography and Performance During Vertical Jumping: A Pilot Study

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ABSTRACT

International Journal of Exercise Science 12(1): 15-23, 2019. Ankle braces have been hypothesized to prevent ankle injuries by restricting range of motion (ROM) and improving proprioception at the ankle. As such, ankle braces are commonly worn by physically active individuals to prevent ankle injuries. Despite their widespread use, the effects that ankle braces have on athletic performance measures, such as vertical jumping, remains unclear. Furthermore, although ankle braces are known to restrict normal ROM at the ankle, little is known about the effects that ankle braces have on the lower extremity proximal to the ankle, specifically muscular activation. Therefore, the purpose of this pilot study was to determine if lower extremity surface electromyographic activity (sEMG) and performance was affected in 5 males and 5 females by wearing softshell (AE) and semi-rigid (T1) ankle braces during a Vertical Jump Test, and to establish a basis for future investigation. Vertical jump height was not significantly affected (p > .05) in the AE (37.49 ± 11.61 cm) and T1 (36.3 ± 11.77 cm) ankle brace conditions, relative to the no brace (38.17 ± 12.01 cm) condition. No significant differences in sEMG of the lateral gastrocnemius and biceps femoris were present across conditions. There was a tendency for sEMG of the rectus femoris to decrease when wearing AE (195.71 ± 100.43 %MVC) and T1 (183.308 ± 92.73 %MVC) braces, compared to no braces (210.08 ± 127.46 %MVC), and warrants further investigation using a larger sample. Until more research is conducted, however, clinicians should not be concerned about ankle braces significantly affecting proximal muscle activation during vertical jumping.

KEY WORDS: Biomechanics, physical performance, muscle function, neurophysiology

INTRODUCTION

Sprains of the lateral ankle ligaments represent the most frequently reported injury in the National Collegiate Athletics Association, with 2429 reported cases between the 2009-10 and

2014-15 seasons (17). Currently, the National Athletic Trainers Association recommends that ankle braces be worn by athletes returning to play from an ankle sprain (9), and a recent systematic review supports their effectiveness for significantly reducing ankle injuries, compared to no bracing (pooled OR 0.40, 95% CI 0.30–0.53; 10). Despite their ability to prevent ankle injuries, recent research has revealed significant decreases in vertical jump height (7,14,18) of up to 2.35 cm (7) when wearing ankle braces. As vertical jumping is an important skill for athletes in sports such as basketball and football (16), a decrease of this magnitude could be the difference between making and not making a catch, blocking or not blocking a shot. Therefore, it has been suggested that further research be conducted on the effects of ankle braces on lower extremity biomechanics and vertical jumping (1,14,18).

The primary mechanism by which ankle braces are hypothesized to prevent ankle injury is by restricting range of motion (ROM) at the ankle (21). Softshell and semi-rigid braces function in different ways to accomplish this. Lace-up style softshell ankle braces generally feature heel-lock and horseshoe straps to restrict motion in the frontal plane, in addition to plantarflexion and dorsiflexion (6). Conversely, semi-rigid braces restrict motion in the frontal plane via hard-shell plastic sides, while theoretically allowing for unrestricted sagittal plane motion (22). Previous literature has suggested that softshell ankle braces may alter knee and hip kinematics by restricting ROM at the ankle, especially during jump landings (5). When landing from a broad jump, softshell braces have been noted to increase knee flexion by 3° (5), although this change was not present when wearing semi-rigid braces during a simulated vertical jump landing (8). As such, how softshell and semi-rigid ankle braces affect lower extremity kinematics during a jump landing may differ. Additionally, how these ankle braces affect biomechanics during a jump take-off remains unclear.

Although the overall body of literature is inconclusive, recent studies have suggested that ankle braces may significantly reduce vertical jump height (7,14,18). Decreases in vertical jump height have previously been attributed to ankle braces restricting plantarflexion and dorsiflexion (1,18). To date, only Smith et al. (18) incorporated biomechanical and electromyographic analysis when investigating a vertical jump with and without ankle braces. When wearing ASO® EVO® (AE) softshell braces, soleus muscle surface electromyographic (sEMG) activity, plantarflexion ROM, peak hip flexion ROM, and vertical jump height were significantly reduced. The observed decrease in vertical jump height was attributed to the reductions in sEMG activity, ankle plantarflexion, and peak hip flexion ROM. Electromyographic activity of the upper leg, however, was not measured. As the quadriceps muscle group acts on both the knee and hip (20), it is possible that sEMG activity of the quadriceps muscles could be affected by changes in hip kinematics. Furthermore, models of vertical jump performance that included hip power, hip torque, and knee extension strength account for up to 60% of the explained variance in vertical jump performance, compared to 21% for ankle angle at take-off (2). Therefore, important biomechanical factors for vertical jump performance may be affected by any changes in quadriceps muscle EMG activity.

Further supporting the notion that ankle braces may affect sEMG activity above the ankle, artificial reduction of plantarflexion ROM has been shown to reduce quadriceps muscle activity during a squat (11). As ankle braces have been shown to significantly restrict ankle plantarflexion (6), it is logical to suggest that wearing ankle braces may have comparable effects on vertical jumping. In elite sport, fractions of an inch or milliseconds can mean the difference between a successful and unsuccessful performance. Given the pervasiveness of ankle brace use in sport, and the importance of optimal performance, how ankle braces affect vertical jump height is an important consideration when deciding whether or not to brace an athlete. Furthermore, vertical jump tests are often considered to have high transferability to sport specific jumping situations (16). Due to observed decreases in vertical jump height in previous studies (7,14,18) it is also necessary to understand the effects that ankle braces have on muscular activity in the lower extremity during a vertical jump. Therefore, the purpose of this pilot study was to determine if the present methodology was feasible to measure potential changes in vertical jump performance, as well as sEMG activity of the lateral gastrocnemius (LG), biceps femoris (BF), and rectus femoris (RF) muscles in healthy, active individuals when wearing softshell and semi-rigid ankle braces. Based on previous literature (7,14,18) it is hypothesized that softshell and semi-rigid ankle braces will reduce jump height, while decreasing LG and RF sEMG activity.

METHODS

Participants

After obtaining ethical approval from the academic institution's research ethics board, 10 healthy, active university students with no prior history of wearing ankle braces participated in this study (Table 1). This number and sample was selected based on the preliminary nature of the study, sample size of previous studies (1, 7), and to acquire sufficient data to perform a-priori analysis for future studies. Prospective participants were included into the study if they 1) were male or female students at the academic institution; 2) were recreationally active, as defined by the Canadian Society For Exercise Physiology (CSEP; 3), participated in at least 150 minutes of moderate to vigorous aerobic activity each week; and 4) were between the ages of 18-30 years. Participants were excluded from participating in the study if they experienced an ankle injury in the last 6 months, or were currently suffering from an acute and/or chronic lower extremity injury. Prior to participating, all participants completed a consent form, as well as a Physical Activity Readiness Questionnaire (PAR-Q; 3) to ensure that they were consenting to participate in the study and medically fit to exercise.

Table 1. Participant demographic information.

	Males (n = 5)	Females (n = 5)
Age (years)	23.2 ±1.3	23.2 ±1.1
Height (cm)	179.7 ±6.36	171.9 ±6.2
Weight (kg)	80±6.7	68.8±3.8

Protocol

A Delsys (Salford, UK) Trigno™ Wireless EMG system and Trigno™ Hybrid sensors were used to collect sEMG data from the participants' dominant leg muscles during the Vertical Jump Test. Raw sEMG data was collected at 1000 Hz per second from the lateral gastrocnemius (LG), biceps femoris (BF), and rectus femoris (RF) muscles. Electrode placement for each muscle was determined using the Surface Electromyography for the Non-Invasive Assessment of Muscles guidelines (SENIAM; Figure 1; 19). To determine take-off period for sEMG analysis, an Advanced Mechanical Technology Incorporated (Watertown, MA) force platform (Model SGA6-4) was used to record vertical ground reaction force (GRF) during the Vertical Jump Test. A Vertec™ device, which has demonstrated good intrasession and intersession reliability (13) was used to measure vertical jump height.

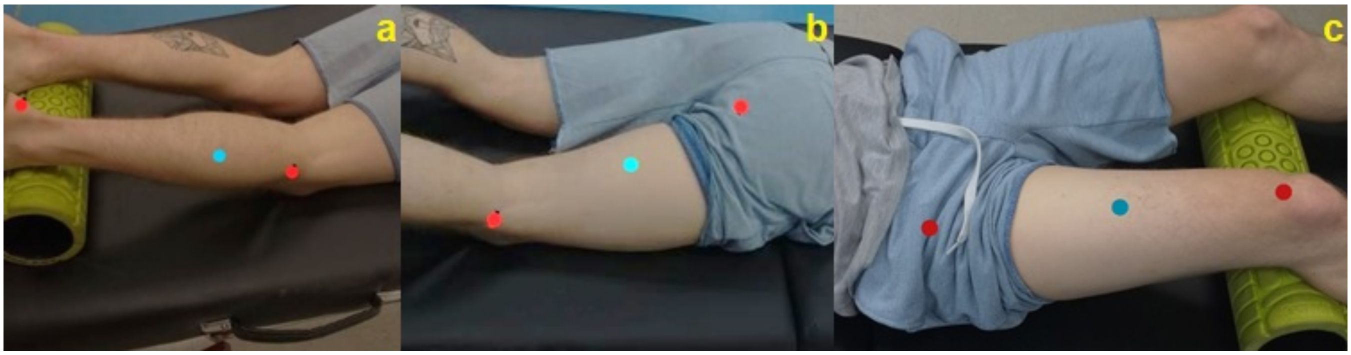

Figure 1. Electrode placement for the LG(a), BF(b), and RF(c) muscles. Red dots represent anatomical landmarks, blue dots represent electrode location.

The Vertical Jump Test was based on the CSEP guidelines (3). Participants positioned themselves parallel to the Vertec™ device, with their feet shoulder width apart and dominant foot on the force platform. Participants initiated a jump by bending at the hip and knees and lowering into a 45° semi-squat position, using their arms as a counterweight. Participants paused for 2 seconds in this position, before jumping and touching the Vertec™ device as high as possible.

A 1-hour session was required to collect all data. After consent was obtained, demographic information, including age (years), height (cm), and weight (kg) was recorded. Participants completed a 5 minute warm-up on a cycle ergometer at a 10-12 on the BORG rating of perceived exertion scale (3). Wireless electrodes were then applied to the participant's dominant leg, defined as the leg that they would kick a soccer ball with. Before applying the electrodes, the skin underlying the electrode sites were prepared by shaving and cleaning the area with isopropyl alcohol to help improve signal attenuation. Standard adhesive interfaces were used to attach the electrode to the participant's skin. After the application of electrodes, a 3 second maximal voluntary contraction (MVC) was performed according to SENIAM guidelines (19), in order, for the LG, BF, and RF muscles.

Following electrode applications and the completion of the MVCs, participants were introduced to the Vertical Jump Test. Before beginning the Vertical Jump Test, the participant's standing reach height was recorded; participants stood erect over the AMTI force platform, perpendicular to a Vertec™ device. The participant then raised his/her dominant arm overhead, touching as high as possible on the Vertec™ device. This height in inches (in) was recorded, and then converted to centimeters (cm) by the researcher. After standing reach was recorded, the participant moved into position to perform the Vertical Jump Test.

After familiarizing themselves with the Vertical Jump Test, participants performed the Vertical Jump Test for 3 best effort jumps, spaced 1 minute apart. For each jump, jump height, raw sEMG, and vertical GRF data were recorded. A 5-minute rest period followed to allow for physical recuperation and to allow time to apply bilateral AE softshell ankle braces (Figure 2). Participants then performed 3 recorded trials, followed by another rest period where they applied Active Ankle T1™ (T1) semi-rigid braces (Figure 3), and performed 3 more jumps.

Figure 2. ASO® EVO® softshell ankle brace.

Figure 3. Active Ankle T1™ semi-rigid ankle brace.

Statistical Analysis
Standing reach height was subtracted from the highest point reached on the Vertec™ device to obtain vertical jump height for each trial. The 3 recorded trials for each ankle brace condition were then averaged and used for statistical analysis.

LabChart© software was used for all EMG analysis. Mean EMG activity was calculated for the take-off phase of the Vertical Jump Test, which was determined using vertical GRF. The takeoff phase was defined as the time at which vertical GRF began to increase (greater than 5 N) from the stationary system weight, to the time that system weight equaled 0 (+/- 5 N; Figure 4). All EMG data was bandpass filtered using a highpass and lowpass cutoff frequency of 10 Hz and 500 Hz, respectively. Following bandpass filtering, all EMG data was lowpass filtered at 10 Hz and full wave rectified. The mean EMG activity values were averaged across the 3 trials and this value was then used for statistical analysis.

A one-way ANOVA for repeated measures was conducted to compare the independent variable (brace condition) on vertical jump height. Significance was determined using an alpha level of $p < .05$. A one-way ANOVA for repeated measures was also conducted to compare the independent variable (brace condition) on mean LG, BF, and RF muscle sEMG activity. Due to the low sample size and number of statistical tests, a Bonferroni adjustment was applied ($p = .05/3$) to reduce the chance of a type I error. As such, significance was determined using an alpha level of $p < .017$. If there was a statistically significant difference between brace conditions, a post hoc analysis using the least significance difference (LSD) was conducted.

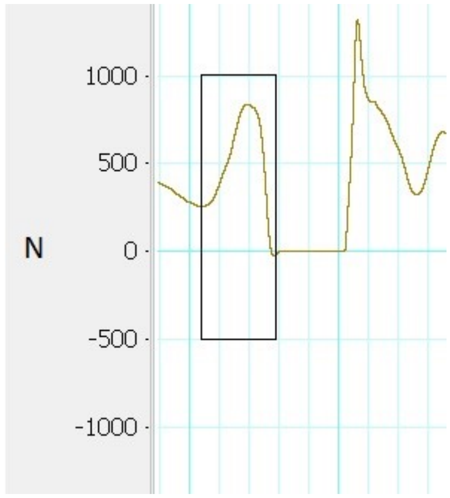

Figure 4. Takeoff phase for the Vertical Jump Test, based on vertical GRF.

RESULTS

No significant difference was observed between brace conditions for vertical jump height, $F(2, 18) = 2.664$, $p = .097$, $\eta p^2 = .228$. Similarly, no significant changes were observed between conditions for mean LG EMG activity, $F(1.281, 11.532) = 1.347$, $p = .282$, $\eta p^2 = .130$; mean BF EMG activity; $F(2, 18) = 0.229$, $p = .797$, $\eta p^2 = .025$; or mean RF EMG activity, $F(2, 18) = 2.812$, $p = .087$, $\eta p^2 = .238$. Means and standard deviations are displayed in Table 2.

Table 2. Descriptive statistics for sEMG and vertical jump height data.

	No Brace		AE		T1	
Muscle	Mean	SD	Mean	SD	Mean	SD
Lateral Gastrocnemius (%MVC)	173.82	103.96	168.50	105.47	158.14	89.27
Biceps Femoris (%MVC)	27.24	15.74	27.58	13.92	29.05	15.67
Rectus Femoris (%MVC)	210.08	127.46	195.71	100.43	183.308	92.73
Vertical Jump Height (cm)	38.17	12.01	37.49	11.61	36.3	11.77

DISCUSSION

The purpose of this pilot study was to determine if the current protocol was feasible to detect potential changes in lower extremity sEMG activity and vertical jump height when wearing softshell and semi-rigid ankle braces during a Vertical Jump Test. Although no significant differences were revealed, there were trends in the data that warrant further investigation. Vertical jump height decreased across ankle brace conditions. Additionally, RF sEMG activity decreased by 14.37 %MVC when wearing the AE ankle braces, while BF sEMG activity remained relatively constant. A similar tendency was also present when wearing the T1 ankle braces. Lateral gastrocnemius sEMG activity was reduced by 5.32 %MVC and 15.68 %MVC when wearing the AE and T1 ankle braces, respectively.

While a significant reduction in vertical jump height was not revealed in this study, there was an average decrease of 1.87 cm when wearing the T1 ankle braces. These results are in line with previous findings noting significant reductions of 2.35 cm (7) and 1.4 cm when wearing semi-rigid ankle braces (14). With respect to AE ankle braces, vertical jump height was comparable to the no brace condition. Using a similar methodology, however, Smith et al. (18) noted a significant decrease in jump height when wearing AE ankle braces. Additionally, as with this study, they noted a non-significant decrease in gastrocnemius sEMG activity and a significant decrease in soleus muscle EMG activity when wearing AE ankle braces. The decrease in vertical jump height was attributed, in part, to a reduction in soleus muscle activation, which alongside the gastrocnemius muscle, acts to plantarflex the foot (20). Smith et al. (18) did not collect upper leg EMG data, but also attributed decreases in jump height to a reduction in peak hip ROM. Although lower extremity kinematics were not examined in this study, there were no significant reductions in RF sEMG activity when wearing both the AE and T1 ankle braces. As the RF muscle acts on the hip and knee (20), it is possible that sEMG activity of the RF may be affected by a change in hip flexion. Given that vertical jump height tended to decrease when wearing the T1 ankle braces, it is possible that this change in RF sEMG activity may affect jump height. Further research is needed, however, to determine if there is a relationship between these variables.

Biceps femoris sEMG activity was relatively unaffected by the AE ankle braces, although there was a slightly greater decrease in BF sEMG activity when wearing the T1 ankle braces. During isokinetic knee flexion, integrated EMG of the BF long head has been noted to decrease linearly from 30° to 120° as knee flexion increases (12). Therefore, the reduction in BF EMG activity may indicate an increase in knee flexion angle during takeoff when wearing the T1 ankle braces, although this cannot be confirmed without kinematic data.

Due to the small sample size (n = 10) of this pilot study, the scope and generalizability of the data is limited. All participants had no prior experience wearing ankle braces. As a method of preventing injury, it is not uncommon for teams in jumping sports to have bracing or taping policies (15). Clinicians have long speculated that these athletes may have biomechanical adaptations from extended use (4). Therefore, it is unknown whether similar effects would have been observed in participants who had experience wearing ankle braces. Furthermore, all participants completed the Vertical Jump Test in the same ankle brace condition order. Since vertical jump height decreased linearly across conditions, it is possible that fatigue may have influenced jump height, as well as sEMG variables. Future studies should address these limitations by increasing the sample size, including participants with prior ankle bracing experience, and counterbalancing the order of ankle brace conditions. Additionally, future research should consider incorporating sEMG, kinetic, and kinematic measures to better understand any biomechanical effects that ankle braces may have on the lower extremity.

While vertical jump height was not significantly decreased in this study, it is important to emphasize that a decrease in vertical jump height has been observed in multiple studies (7,14,18) and the mechanism(s) behind these decreases have not been clearly determined. With respect to sEMG data, again, no significant changes were observed in the current study, although LG and RF sEMG activity was lower in all ankle brace conditions compared to no brace. Therefore, while the current study does not indicate that ankle braces affect vertical jump height or lower extremity sEMG activity, it does not support the lack of an effect. As no significant effect of AE or T1 ankle braces was revealed in this study, clinicians should continue to prescribe ankle braces for injury prevention within the context of the overall body of literature, situation, and recommendations of their respective governing bodies until more evidence is gathered.

In conjunction with the results of previous investigations, the results of this pilot study provide the basis for further investigation into the effects that ankle braces may have on athletic performance and sEMG activity of the lower extremity, using a similar methodology. Specifically, the effects that ankle braces may have in pathological and athletic populations, as well as in persons with and without experience wearing ankle braces. This will allow athletes, coaches, and clinicians to better understand the mechanisms that may be behind potential decreases in athletic performance when wearing ankle braces. Until further research is conducted, prescribers and users of ankle braces should continue to do so in an effort to reduce the risk of ankle injury.

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