ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

MECHANICAL EFFECT OF AN ANKLE BRACE DURING LANDING: PRELIMINARY RESULTS

[1]Ilias Theodorakos, [1]Jan Rueterbories, [2]Michael S. Andersen, [1]Mark de Zee and [1]Uwe G. Kersting
[1]Department of Health Science and Technology, Aalborg University, Denmark
[2] Department of Mechanical and Manufacturing Engineering, Aalborg University, Denmark;
email: ith@hst.aau.dk, web: www.smi.hst.aau.dk

SUMMARY

The purpose of this study was to determine the effect of an ankle brace during landing on inclined surfaces. Ten healthy volunteers were instructed to perform a landing task on a tilted force platform. The task was performed with and without an ankle brace. Ground reaction forces (GRF) and electromyographic (EMG) activity of five lower extremity muscles were collected.

The results showed a significant decrease of the triceps surae activity for the braced trials compared to the unbraced condition. This suggests a negative effect of the ankle brace on the neuromuscular response. A full kinematic analysis is currently under way.

INTRODUCTION

Ankle sprains are the most common injuries in sports, causing an economic burden for health care systems [3]. Previous studies [1] have investigated related risk factors such as sport or work requirements, previous history of ankle sprain injury and sex. However, the underlying injury mechanism remains unclear. A detailed investigation of the loading in potentially high risk situations might support the understanding of the underlying injury mechanics.

Ankle bracing is a common intervention to reduce the incidence of ankle sprain injury and seems to be specifically beneficial for players with a previous ankle injury or established instability [7]. The effectiveness of external ankle support has been investigated in biomechanical studies by means of trap door or tilt platform mechanisms. Landing on inclined surfaces simulate ankle sprain better than the inversion drop test [8].

The purpose of the study was to assess the effect of an ankle brace in injury prone landings on the measured kinematics and EMG activity data using inclined surfaces.

METHODS

Ten healthy men (height 1.78 ± 0.07 m, weight 75.1 ± 6.6 kg, age 26.6 ± 4.4 years) with no prior ankle injuries participated in the study. Participants were asked to perform a landing task from a height of 40 cm on a robotic force platform [12]. The force plate was randomly inclined at four different angles producing 5° eversion or 0°, 10° and 15° inversion. Participants were instructed to perform the task by using their dominant leg and starting from a defined position (Figure 1). The landing task was repeated seven times per inclination with and without an ankle brace (Figure 1). A trial was considered successful when the participants were able to land with the testing leg on the force plate and maintained their balance on that leg for at least 2 s. All participants wore the same shoe model in order to avoid variations in footwear (FZ FORZA, Denmark).

Figure 1: Left: The starting position for a trial performed with the right leg. Right: Air-Stirrup® ankle brace.

A force plate (AMTI, Watertown, USA) was used to measure GRF at 4 kHz. The EMG activity of tibialis anterior (TA), soleus (SO), lateral and medial gastrocnemius (GL, GM) and peroneus longus (PL) muscles was recorded (Biovision, Wehrheim, Germany) at 2 kHz. All data were time synchronized.

GRF were normalized to body weight (BW). Peak GRF values were identified for each trial. The EMG muscle activity was normalized to the peak muscle activity for each subject. The most favorable method for quantifying muscle activation is the integrated EMG (iEMG), when utilizing surface EMG for kinesiological applications [10]. In order to identify the muscle preparation during landing, the iEMG activity was calculated over the period of 200 ms before the initial contact (IC) of the foot with the platform. This period was defined as pre-IC period (PRE). It has been reported that pre-muscle activity during landing occurs approximately 200 ms before IC [9]. Furthermore, the iEMG of the periods 0-50 ms and 51-200 ms after IC were calculated to examine potential differences between monosynaptic reflex contributions and voluntary alterations in EMG. The period 0-50 ms after IC was defined as early contact (ECO), while the 51-200 ms as late contact period (LCO).

Two independent variables were tested: the inclination of the platform and the brace condition. The first factor (inclination) had four levels (-5°, 0°, 10° and 15°), while the second had two levels (braced and unbraced trials). Two-way (4x2) repeated measures ANOVAs was applied for group differences in GRF and EMG activity variables. The mean values of the respective dependent variables for seven repetitions per group were used for each test. A commercially available statistical analysis package SPSS v.20 (IBM Corp®) was used for statistical analysis. The significance value was set at p = 0.05 for all analyses. As the hypothesis addressed primarily a putative effect of the brace on GRF and EMG activity, only data and statistics for this comparison are presented in the results.

RESULTS AND DISCUSSION

No interaction between the factors was found. A decrease in GRF and EMG activity variables was shown for the braced versus unbraced trials (Table 1). The peak value of the vertical GRF (Fz) was significantly greater for the unbraced trials ($F_{(1,9)} = 5.165$, $p = 0.049$). On the other hand, no significant differences were found for the remaining GRF components.

The results showed that the brace affected the activity of the triceps surae muscles. Contraction of those muscles induces plantar flexion and inversion possibly supporting stabilization of the ankle complex about the subtalar joint. The PRE iEMG of GM ($F_{(1,9)} = 16.139$, $p = 0.03$), GL ($F_{(1,9)} = 30.822$, $p < 0.001$) and of SO ($F_{(1,9)} = 10.023$, $p = 0.011$) were significantly lower for the braced trials. This reduction of the pre-activation of triceps surae muscles was linked to a reduction of the peak Fz, most likely caused by a reduced joint stiffness (the kinematic analysis will provide an improved basis of understanding). The ECO iEMG of GM ($F_{(1,9)} = 25.209$, $p = 0.001$) and GL ($F_{(1,9)} = 20.556$, $p = 0.001$) were decreased for the brace condition. A reduction for SO ($F_{(1,9)} = 5.441$, $p = 0.045$) and for GL ($F_{(1,9)} = 14.521$, $p = 0.004$) in LCO iEMG were observed. The post IC reductions in the activity of triceps surae muscles may be explained by the observed reduction on the Fz. The differences in the ECO and LCO could be explained by muscles differences in regard to their structure, anatomical position, function, and fiber type characteristics [11]. Gastrocnemius, with its higher percentage of fast contracting fibers, might produce greater activity during faster, more explosive movements [4,6]. The brace seems to restrict the activity of GM and GL during the ECO. In contrast, the SO activity remained unchanged during that period, but was reduced during the late period. SO with its slower fibers, might be more active during movements of lower intensity and longer duration [4,5]. Reductions for GL and SO were observed in LCO, but the GM remained unaffected. Although triceps surae muscles share a common insertion, they have different origins. Possible alterations in the range of joint motion due to the brace would cause different muscle forces. Kinematic analysis could provide for a more comprehensive insight into these results. Although, no significant differences were found for TA and PL muscles, reductions of 28.6% and 21.7% were observed for PL iEMG druing PRE and LCO, respectively.

CONCLUSIONS

Bracing seems to be associated with reductions to mean values in Fz and EMG variables during landing. Significantly lower values of the triceps surae iEMG for both before and after IC periods were observed for the braced compared to the unbraced condition. The latter indicates that the ankle brace is detrimental to the neuromuscular response [2]. However, we will be able to discuss these results in more detail once the study has been completed by collecting data on more subjects and including a full kinematic analysis.

ACKNOWLEDGEMENTS

This study was funded by Det Frie Forskningsråd, Teknologi og Produktion (FTP), Grant nr. 10-082524. The ankle braces were provided by the DJO Global company.

REFERENCES

1. Baumhauer JF, et al., *Am J Sports Med.* **23**:564-70, 1995.
2. Brent LA, et al., *Clin Sports Med.* **23:** 83– 95, 2004.
3. Fong DTP, et al., *Sports Med.* **37**:73-94, 2007.
4. Enoka RM, et al., *Isokinet Exerc. Sci*. **6**:71–77, 1996.
5. Gollnick PD, et al., *Pflugers Arch.* **348**:247–255, 1974.
6. Green HJ, et al., *J. Neurol. Sci*. **52**:200–210, 1981.
7. Gross, et al., *J Orthop Sports Phys The.*, **33**:572-7, 2003.
8. Qingjian C, *Master's Thesis, University of Tennessee*, 2009.
9. Santello M, et al., *Exp Physiol.* **83**: 857-874, 1998.
10. SENIAM, http://www.seniam.org, 2006.
11. Signorile JF, et al., *J. Strength Cond. Res*. **16**: 433–439, 2002.
12. van Doornik J, et al, *IEEE Trans Biomed Eng.* **54**:1696-702, 2007.

Table 1: Mean values percentage reduction of variables for the braced (WB) versus unbraced (NB) trials. The iEMG variables in normalized EMG ampl.· ms.

Variable		Peak Fz	GM PRE	GL PRE	SO PRE	GM ECO	GL ECO	GM LCO	SO LCO
P-value		0.049	0.030	< 0.001	0.011	0.001	0.001	0.004	0.045
Mean value ± (SD)	NB	3.9 0.3	123.0 11.1	120.8 8.5	80.3 16.7	40.2 4.5	40.3 3.2	89.8 16.1	135.0 12.0
	WB	3.7 0.2	99.4 14.0	82.3 11.4	41.2 5.9	25.5 3.4	25.6 3.0	71.5 12.0	116.5 8.3
Reduction (%)		4.7	19.2	31.9	48.7	36.6	36.5	20.4	13.7