BIOMECHANICAL EFFECTS OF HIKING ON A NON-UNIFORM SURFACE

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INTRODUCTION

Footwear is often designed for a specific purpose dictated by the functional requirements of an intended activity. In the case of hiking footwear, the non-uniform terrain provides exposure to certain situations which influence hiking boot design. The possibility of an acute ankle injury has led to the incorporation of increased ankle stability in the hiking boot design but the functional requirements are yet unknown. Exactly what biomechanical effects are caused by walking on an uneven surface has yet to be explored and remains unpublished. Therefore, the purpose of this study was to explore the biomechanical effects of hiking on a non-uniform surface.

METHODOLOGY

Ten healthy male subjects were recruited for this investigation. Data from the right shank and foot were collected while walking (1.4 m/s ± 5%) in a Raichle Mountain Trail GTX hiking boot. Two different surfaces were used. The first was a non-uniform surface created to simulate hiking terrain. This surface was made by setting exposed rock in concrete and had a height of 90mm from the floor to the top of the rocks. This surface was compared to the laboratory floor. For each subject, the order of the surfaces was randomly assigned and ten walking trials were collected.

Kinetic data were collected with a Kistler force platform sampling at 2400 Hz. Concurrent electromyography (EMG) measurements were collected on the vastus medialis, biceps femoris, gastrocnemius and tibialis anterior muscles. EMG data were collected with Ag/AgCl bipolar electrodes (novotrode 20; interelectrode spacing 2.2 cm) sampling at 2400 Hz. Analysis of the EMG data consisted of calculating the root mean square of the activity of each muscle during the stance phase and normalizing to the observed activity found for the standard floor. Kinematic data were collected simultaneously with the kinetic and EMG data using a Motion Analysis eight video camera system at 240 Hz. Spherical reflective markers were placed on the shank, shoe and foot for kinematic data collection. Kintrak software was used for data analysis.

Outcome variables explored include impact forces and rates, ankle eversion angles, ankle moments, knee moments, and muscle activity. The ten trials were averaged and a paired t-test used to determine statistical differences at an alpha level of 0.05.

RESULTS

All outcome variables are presented in tables 1 and 2 as means and standard deviations as well as the corresponding p-values. The p-values of those variables with a statistically significant difference are presented in bold font.

The non-uniform surface significantly increased the rate of impact force by 16.7 percent compared to the regular surface. Two muscles provided statistical differences. In comparison to the regular surface, the non-uniform surface showed a decrease in the tibialis anterior and an increase in the biceps femoris muscle activity. No differences in joint moments were found.

Although no other statistically significant differences were observed, there are some interesting trends. There appears to be a decrease in ankle eversion angle as well as a possible decrease in the knee external rotation moment on the rocky, non-uniform surface.

Table 1. Force, eversion, and muscle activity variables for both the normal and non-uniform surfaces presented as means and (standard deviations). Statistically significant differences are represented with a bold font p-value.

Surface	Impact Force [N]	Impact Rate [N/s]	Eversion Angle [deg]	Tibialis Anterior [%]	Vastus Medialis [%]	Biceps Femoris [%]	Gastrocnemius [%]
NORMAL	370 (90)	14854 (2072)	9.4 (2.0)	100 (0)	100 (0)	100 (0)	100 (0)
NON-UNIFORM	390 (63)	17331 (2692)	8.3 (1.8)	78 (13)	92 (20)	118 (24)	95 (11)
p-value	0.280	**0.003**	0.083	**0.001**	0.251	**0.041**	0.200

Table 2. Ankle and Knee moment variables for both the normal and non-uniform surfaces presented as means and (standard deviations).

Surface	Ankle Plantarflexion Moment [Nm]	Ankle Inversion Moment [Nm]	Ankle Abduction Moment [Nm]	Knee Extension Moment [Nm]	Knee Abduction Moment [Nm]	Knee External Rotation Moment [Nm]
NORMAL	110.9 (15.1)	16.9 (4.5)	12.8 (2.0)	40.8 (13.5)	35.4 (9.9)	12.0 (3.0)
NON-UNIFORM	110.6 (14.8)	17.1 (4.2)	12.6 (2.2)	41.2 (11.9)	35.2 (10.2)	11.2 (2.6)
p-value	0.876	0.672	0.754	0.774	0.881	0.076

DISCUSSION

As different muscle activation was used to produce similar joint energetics. Despite the decrease in tibialis anterior muscle activity for the non-uniform surface, peak ankle plantarflexion moments are essentially the same. Similarly, the increase in biceps femoris activity on the non-uniform surface is associated with no change in the knee extension moment. The observed change in impact rate while walking on the rocky, non-uniform surface suggests possible increases in cushioning for hiking boots. Trends towards decreased eversion could possibly be explained by a more cautious gait pattern on the non-uniform surface.

In order to satisfy the current assumptions of hiking boot requirements, hiking boots are generally heavier and more restrictive in their movement than a regular shoe. These design differences found in hiking boots may not only provide the desired functional characteristics but may also cause other biomechanical changes. Therefore, data exploring the biomechanical differences between current hiking specific footwear and normal athletic running shoes will be explored.

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