

A COMPARISON OF NEGATIVE HEEL SHOES AND NORMAL LOW POSITIVE SHOES USING GROUND REACTION FORCE MEASUREMENTS

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INTRODUCTION

The negative heel shoe (NHS), or ‘missing heel’ shoe in some literature, has drawn considerable research attention. Benz et al. (1998) compared missing heel shoes and normal shoe-sole geometry shoes and found that significant differences existed in ground reaction force (GRF) parameters until mid-stance. The shape of the GRF curve was markedly different between the normal and missing heel shoes. Mann et al. (1976) also demonstrated that the overall magnitude of the initial vertical force was diminished. Due to the bimodal curves having two maximum GRFs, and the first maximum GRF reported as being decreased, what happened in the second maximum GRF and what will be the period of time between the two maximum GRF? Ebbeling et al. (1994) demonstrated that during walking in high heel shoes, the subject’s center of mass shifted forward and the first and second maximal GRF increased during the support phase. Snow et al. (1994) reported that with an increase in heel height, the occurrence of both the minimum (at mid-stance) and maximum vertical force during the second half of support, was delayed. If the claims are correct, it can be inferred that wearing NHS should move the center of mass backward and diminish the first and second maximal GRF. In addition, the time characteristics during contact should be different. To our knowledge these relationships have not been well investigated. The purpose of this study was to provide detailed information on the changes of GRF with wearing NHS compared with normal Low Positive Heel shoes (LPHS).

METHODS

Thirteen male subjects of mean age 23.08 yr (SD, 3.9), mean height 1.63 m (SD, 0.05) and mean body mass 50.18 kg (SD, 5.3) volunteered to participate in this study. All subjects were in an excellent state of health. No previous histories of muscle weakness, neurological disease or drug therapy were reported. Each subject provided informal consent according to the local ethical committee’s guidelines. To assure uniformity of the testing conditions all subjects were provided with the same two kinds of shoes. Although LPHS and NHS were commercially available, they were similar in construction and material with the exception of the heel height. LPHS (Figure 1) tilts the sole into 10 degrees of plantarflexion while the NHS (Figure 2) tilts the sole into 10 degrees of dorsiflexion. Different sizes of shoes have different heel heights. In this study, only shoes of size 37 were studied. In LPHS the heel was approximately 2 cm higher than the toe. In contrast the toe in the NHS was 2 cm higher than the heel. For each subject, the order of the shoes was randomly assigned in each different test session.

GRF data were collected using a force platform (Kister, Type 9281C, Switzerland) with a sampling rate of 500 Hz. The force platform was installed flush with floor in the middle of a 10 m walkway. Subjects were provided multiple practice trials to become familiar with the data collection protocol. Walking speed was 1.33 m/s. The subjects were asked to focus on a point on the wall positioned 150 cm above the floor lying directly in the front of their walking path. For normal gait, visual inspection of the researcher was used to detect overt targeting to the force platform. Only walking trials within 5% of the target speed through all force platform contact intervals were accepted for analysis. Ten successful trials were collected in each pair of shoes. The 2 to 3 min break required to change shoes was deemed adequate to negate any possible fatigue effects, which were minimal considering the walking pace used in the study and the regular activity level of the subjects. A set of five variables describing the initial impact phase of gait was measured from the vertical ground reaction force curve of each trial using custom software. A threshold of 10 N in the vertical GRF was used to identify the onset of foot contact. Differences between results were tested with paired-samples t test and the level of significant was determined at $p < 0.05$ using SPSS.

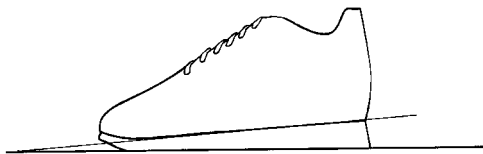


Figure 1-Lower Positive Heel Shoes



Figure 2-Negative Heel Shoes

RESULTS AND DISCUSSION

The ground reaction force values were converted to units of body weight (%BW). Various time interval data were normalized to the contact time (%CT) with the exception of whole contact time. Table 1 shows that the contact time, time interval from initial contact to minimum force, and from minimum force to take-off were significantly different ($p < 0.05$). The first maximal force and second maximum force were significantly different ($p < 0.05$), but minimum force was not significantly different ($p > 0.05$) between LPHS and NHS.

Table 1- Statistical results of GRF parameters for all subjects wearing LPHS and NHS during floor walking

Parameter	LPHS		NHS		Statistical comparison	
	Mean	SD	Mean	SD	T	P
Time from IC to Min. force (%CT)	48.8547	2.1557	46.2787	2.8435	6.103	0.000
Time from Min. force to take off (%CT)	51.1453	2.1557	53.7213	2.8435	-6.103	0.000
Total IC (s)	0.6859	0.0346	0.6705	0.0294	3.191	0.008
First Max. force (%BW)	117.2846	6.8367	113.7108	7.5722	3.847	0.002
Min. force (%BW)	72.2146	6.8517	73.7392	7.3544	-2.173	0.051
Second Max. force (%BW)	113.7592	4.3780	110.9854	4.3575	4.651	0.001

Max.=maximum; Min.=minimum; CT=contact time; BW=body weight

The shape of the GRF curves was markedly different between the two conditions. Ebbeling et al. (1994) reported that when wearing high heels, the center of mass is moved forward, causing an increase of the first and second maximum vertical GRF component. The present study proved that wearing NHS moved the center of mass backward and decreased the first and second maximum vertical GRF. The shape of the bimodal curve with NHS was flatter than with LPHS. In addition, the time intervals from minimum GRF to take-off were significantly higher with NHS than with LPHS.

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