The biomechanical effects of shoe heel height
－Ankle range of motion－

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SUMMARY

This study aimed to unveil the effects of shoe heel height on biomechanical characteristics of lower limb joints. Eight female students participated in this study. The joint angle and joint moment were measured using a three-dimensional motion analyzer (VICON); surface electromyography (EMG) of 7 muscles was recorded simultaneously. Four pairs of shoes with 0 mm, 30 mm, 60 mm, and 90 mm heel heights were used. The subjects walked with each of these at a comfortable gait speed. There was a significant difference in ankle motion and knee joints in the sagittal plane between various heel heights. The ankle range of motion throughout the period of mid stance, from the time of heel contact was completion of the walking cycle, showed a significant increase with an increase in heel height (0 mm versus 90 mm and 30 mm versus 90 mm). Significant differences were seen in the knee angle at heel contact between different heel heights (0 mm versus 90 mm and 30 mm versus 90 mm). The EMG findings of 7 muscles were not significantly different across the various heel heights. It is important to increase the knee angle with an increase in the ankle range of motion.

INTRODUCTION

High-heeled shoes are in fashion since recent years and are used by young girls and women. However, they are not aware of the influence of high heels on knee, hip, and other joints. High heels reportedly pose several risks, for example, tendency to fall off the stairs and traffic accidents. In this study, we investigated and analysed joint angles and EMG data of lower limb muscles throughout mid stance, from the time of heel contact to completion of the walking cycle, to clarify the effects of high heels.

METHODS

Subjects: Eight healthy female students participated in this study. Their mean (standard deviation) age, height, and weight were 18.7 (0.7) years, 155.1 (5.1) cm, and 52.2 (4.8) kg, respectively. Prior to measurements, the purpose and procedure of this study were explained in detail, and informed written consent was obtained from all subjects.

High heels: We used shoe heel heights that were representative samples: 0 mm, 30 mm, 60 mm, and 90 mm (Figure 1).

Materials: VICON system was used to capture three-dimensional movements. The sampling frequency was 100 Hz. The system was equipped with 6 infrared cameras and 4 force plates, and there were 35 markers (plug-in gait) for each subject. Disposable bipolar electrodes were attached to the skin over each muscle, using an adhesive gel. The centre of electrodes was placed on the midline of the muscle belly, and the electrodes were directed along the longitudinal muscle fibres. Disposable electrodes were attached on the right side of biceps femoris, rectus femoris, lateral gastrocnemius, anterior tibial, obliquus externus abdominis, iliocostalis lumborum, and multifidus muscles. EMG sampling frequency was 1000 Hz. Rectified filtered electromyography (RFEMG) was employed; in this method, the potential obtained is converted to 100 Hz to make it acceptable by the VICON system. For RFEMG measurements, a low-cut filter at 10 Hz and a height-cut filter at 500 Hz were used, and the RFEMG data were preserved in a personal computer. The data of VICON and surface EMG signals of the muscles were recorded while subjects walked, throughout mid stance from the time of heel contact to the completion of the walking cycle. Statistical analysis was conducted using one-factor ANOVA and Tukey-Kramer test. Subjects wore shoes with different heel heights. Before the measurements, the subjects were allowed to practice walking with each shoe set to achieve a comfortable gait.

Figure1. Different shoe heel heights were used.
From left to right: 0 mm, 30 mm, 60 mm, and 90 mm heels.

RESULTS AND DISCUSSION

The motion of ankle and knee joints in the sagittal plane differed significantly between different heel heights. The ankle range of motion showed a significant increase with an increase in heel height (0 mm versus 90 mm and 30 mm versus 90 mm) (figure 2). Similarly, knee angle also showed a significant difference with an increase in heel height (0 mm

versus 90 mm and 30 mm versus 90 mm) (figure 3). Thus, it is important to increase the angle of knee with an increase in the ankle range of motion.

References

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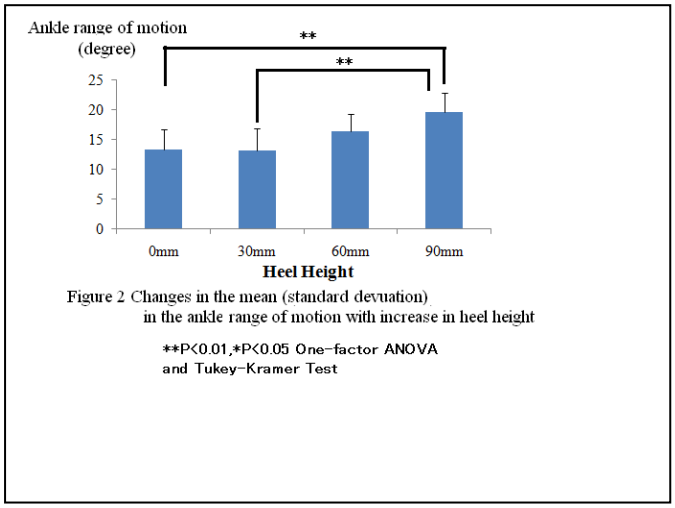

Figure 2 Changes in the mean (standard devuation) in the ankle range of motion with increase in heel height

**P<0.01,*P<0.05 One-factor ANOVA and Tukey-Kramer Test

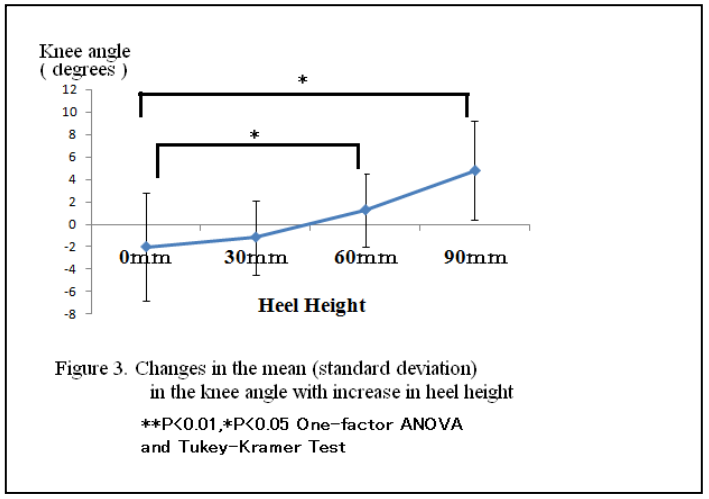

Figure 3. Changes in the mean (standard deviation) in the knee angle with increase in heel height

**P<0.01,*P<0.05 One-factor ANOVA and Tukey-Kramer Test