SIMULATION OF BIOMECHANICAL INFLUENCE OF HIGH HEELS ON MUSCULOSKELETAL SYSTEM OF FOOT AND ANKLE

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INTRODUCTION

High-heeled shoes are preferred by all women to enhance beauty and charm. However, many of those who wear high heels for extended periods complain of foot pain[4]. This is because the foot bears a considerable load during the high-heel gait. This can cause serious deformation of the foot, such as hallux valgus deformity[2]. We simulated the high-heel gait on a computer and performed inverse dynamic analysis to calculate the joint reaction forces and torque on the ankle and a toe. This allowed an investigation into how high-heeled shoes affect the foot and ankle kinetically.

METHODS

Six healthy female subjects (average height, 162.56cm; weight, 47.21kg) who were accustomed to wearing high-heeled shoes participated in this study. We performed experiments with three different heel sizes (high, 7.5 cm; mid, 5.5 cm; low, 3 cm). We captured the gait motion with high heels using the Qualysis Motion Capture System (Qualysis, Gothenburg, Sweden). The motion was recorded by capturing the displacement of attached markers using 11 cameras at a uniform rate of 60 Hz. The ground reaction forces (GRF) were measured on one AMTI force plate (Model OR6-7, Advanced Mechanical Technology Inc., Watertown, MA, USA). The markers were attached to the right side of the lower extremity, following the Oxford Foot Model marker set.

The coordinates from the 3D positions data for the markers were then used to calculate the joint angles for the ankle and toe joints (metatarsophalangeal joint). The three segments of the lower extremity model were developed using ANYBODY (ANYBODY Technology, Aalborg), which is a modeling program for the musculoskeletal system. The model consisted of the shank, fore foot, and toe. The foot segment was a multi-segment model, which allowed more realistic analysis of foot motion than a model with just one segment. We entered the joint angle data into the model and calculated the joint reaction forces and torques on the ankle and toe joints. The muscle activation of the extensor hallucis longus (EHL), which was considered to be the most activated by the high-heel gait, was also derived by inverse dynamic analysis.

RESULTS AND DISCUSSION

Figure 1 shows the results of the experiments. The joint reaction forces (in sagittal plane) and torques (in lateral axis) on the ankle and toe joints increased with the heel size. The muscle activation of the EHL was also higher with the high-heeled and mid-heeled shoes than with the low-heeled shoes.

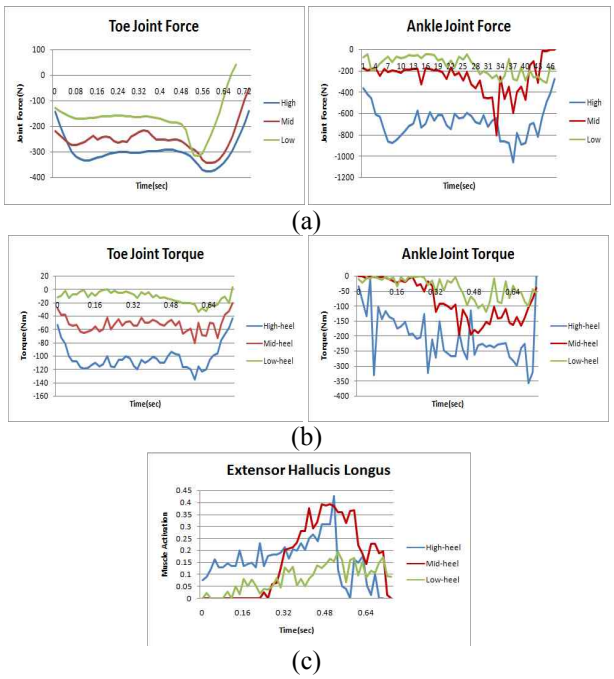

Figure 1: (a) Joint reaction forces of ankle and toe versus time. (b) Joint reaction torques of ankle and toe versus time. (c) Muscle activation of EHL versus time(blue – High-heel, red – Mid-heel, green – low-heel).

CONCLUSIONS

The results show that high-heeled shoes increase the forces and torques on the ankle and toe joints. The muscle activation of the foot muscle attached to the toe and forefoot also increase with high-heeled shoes. Therefore, compared with a low-heeled shoe, a mid-heeled or high-heeled shoe can create excessive loads on the foot. These excessive loads may cause deformations of the foot if they last extended periods.

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REFERENCES

1. Gefen A, et al., *Gait and Posture.* **15**:56-63, 2002.
2. Yu J, et al., *Clinical Biomechanics* **23**:S31-S38, 2007.
3. Plamondon A, et al., *Clinical Biomechanics* **11**:101-110, 1996.
4. Lee C, et al., *Industrial Ergonomics* 28:321-326,2001.