Effect of Tight-fitting High-heeled Shoes on the Activities of the VMO, BF, and GCM Muscles during Stair Ascent

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Abstract. [Purpose] The purpose of this study was to investigate the effects of tight-fitting high-heeled shoes on vastus medialis oblique (VMO), biceps femoris (BF), and gastrocnemius (GCM) during stair ascent. [Subjects] Fifteen female subjects were recruited. [Methods] The subjects ascended stairs with a step height of 20 cm wearing loose- and tight-fitting high-heeled shoes, and the activities of the VMO, BF and GCM muscles were recorded using EMG. [Results] The normalized EMG data of the VMO muscle significantly decreased when wearing the tight high-heeled shoes during ascend the stair compared to loose high-heeled shoes. The normalized EMG data of the BF, and GCM muscles significantly increased when wearing the tight high-heeled shoes compared to loose high-heeled shoes during stair ascent. [Conclusion] We think that tight-fitting high-heeled shoes may more easily cause muscle imbalance; therefore, tight-fitting high-heeled shoes would raise the risk of musculoskeletal disorders in young women.

Key words: Electromyography, Stair ascent, Tight high-heeled shoes

INTRODUCTION

In recent times, young women are wearing high-heeled rather than low-heeled shoes to make themselves look taller or slimmer and more fashionable1–3. The habitual wearing of high-heeled shoes has been shown to cause knee pain, foot pain, foot deformity, and alteration of normal gait patterns4–6. Recently, the wearing of tight-fitting high-heeled shoes has become fashionable. Previous studies have shown the effect of tight garments on the human body, and have reported how tight jeans can restricting blood circulation and lymph fluid7, 8. Yoo et al.9) also suggested the need for studies into the relationship between musculoskeletal disorders and the wearing of tight-fitting garments. The effects of type and height of shoe heels on the body have revealed that the lower extremity mechanics and the energy cost differ with heel height9. However, few studies have investigated the effects of wearing tight-fitting high-heeled shoes. Therefore, the aim of this study was to provide an efficient evaluation of the impact of wearing tight-fitting high-heeled shoes on the functions of the vastus medialis oblique (VMO), biceps femoris (BF), and gastrocnemius (GCM) muscles during stair ascent.

SUBJECTS AND METHODS

The subjects of this study were 15 females in their twenties who wore high-heeled shoes for more than six hours daily (age: 22.7 ± 1.5 years [mean ± SD]; height: 167.1 ± 4.9 cm; weight: 56.7 ± 7.5 kg; duration of wearing high-heeled shoes: 6.2 ± 1.7 hours/day). None of the subjects had a history of ankle joint injury, foot deformities, or dysfunctional neuromuscular or musculoskeletal system. The muscle activities of the VMO, BF, and GCM muscles were recorded using a MP150 system and circular surface EMG disposable electrodes (3.5 mm diameter). All of the EMG signals were sampled at 1000 Hz, and then analyzed using Acqknowledge 3.9.1 software (Biopac Systems, Santa Barbara, CA, USA). The root mean square values of the raw data were calculated, with the amplitude normalized to the maximum voluntary isometric contraction. The subjects wore loose-fitting or tight-fitting high-heeled shoes and ascended stairs with a step height of 20 cm, while the activities of VMO, BF, and GCM were recorded using surface electromyography. We selected the loose-fitting and tight-fitting high-heeled shoes from the models of Y Company. We selected shoes with 7-cm high heels of various sizes from 230 to 250 mm, all of which had the same design in order to avoid design-related effects. The loose-fitting high-heeled shoes were tightened to 100–105% of the subjects’ foot width and length, and the tight-fitting high-heeled shoes were tightened to 90–95% of the subjects’ foot width and length. The subjects stood at the foot of the stairs, and when instructed to “start”, they began climbing with their left leg at a rate of 80 steps per minute, stepping on alternate sides while wearing either the loose-fitting or tight-fitting high-heeled shoes. The SPSS statistical package (SPSS, Chicago, IL) was used to analyze differences in the VMO, BF, and GCM muscle activities. The significance of
differences between loose-fitting and tight-fitting shoes was tested using the paired t-test, with significance accepted at values of p<0.05.

RESULTS

The normalized EMG data of the VMO muscle significantly decreased (p<0.05) when subjects wore the tight-fitting (48.8 ± 12.5%) compared to the loose-fitting (56.4 ± 10.7%) high-heeled shoes during stair ascent. The normalized EMG data of the BF muscle significantly increased (p<0.05) when the subjects wore the tight-fitting (58.7 ± 19.0) compared to the loose-fitting (42.8 ± 9.7) high-heeled shoes during stair ascent. The normalized EMG data of the GCM muscle significantly increased (p<0.05) when subjects wore the tight-fitting (41.6 ± 11.5%) compared to the loose-fitting (32.1 ± 11.6%) high-heeled shoes during stair ascent.

DISCUSSION

The VMO muscle activity significantly decreased when subjects wore the tight-fitting compared to loose-fitting high-heeled shoes while ascending the stairs. The activity of the quadriceps was enhanced and that of the GCM was reduced when female workers ascended stairs wearing high-heeled shoes[5]. However, in the present study, the GCM muscle activity significantly increased and that of the VMO muscle decreased when subjects wore the tight-fitting high-heeled shoes during stair ascent. Patients with patellofemoral pain usually have weakness in VMO. The daily repetition of wearing of tight-fitting high-heeled shoes may cause abnormal stair ascent, and it may cause an imbalance in the thigh muscles, such as VL and VMO[5]. The activity of the BF muscle showed no significant increases when subjects wore the tight-fitting compared to the loose-fitting high-heeled shoes during stair ascent. Gadgosik et al.[9] also reported that hamstring shortening was associated with limitation of lumbar spine flexion, which contributed to low back pain. We think that tight-fitting high-heeled shoes may more readily facilitate hamstring shortening; therefore, the wearing of tight-fitting shoes would raise the risk of back pain in young women. The normalized EMG data for the GCM muscle showed significant increases when the subjects wore the tight-fitting high-heeled shoes during stair ascent compared to when they wore the loose-fitting high-heeled shoes. Wearing high-heeled shoes may induce lengthening of the tibiofemoral lever arm, due to extension of the lower leg, in response to the excessive height of the heel[2]. We think that a tight-fitting high-heeled shoe would increase the peak pressure on the metatarsal head and raise the medial arch. The tight-fitting high-heeled shoes also would also increase the pressure and decrease the contact area of the metatarsal due to toe flexion. For this reason, fatigue of the GCM would be expected to increase.

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