J Int Acad Phys Ther Res 2011; 2(2): 267-343
ISSN 2092-8475
www.iaptr.org
http://dx.doi.org/10.5854/JIAPTR.2011.2.2.324

Comparison Analysis of Lower Extremities Activity while Walking Downhill according to the Height of Heel for Women in 20's

The purpose of this study is to measure the effect of change in heel height on lower extremities activity of young women on high-heeled shoes that young women prefer from more kinetic and realistic perspective as this study changes the degree of slope on a treadmill. The study subjects are 15 young and healthy women who do not have any external injuries or problem with walking and understand the purpose of this study clearly. They wore three different height of heels(1cm, 7cm, 12cm) and walked on a treadmill at a constant speed of 3km/h. EMG value of four muscles (anterior tibial muscle, gastrocnemius muscle, straight muscle of thigh, and biceps muscle of thigh) were collected when walking and the change according to the height of heels were analyzed using one-way ANOVA. Multiple comparison analysis on anterior tibial muscle and heel height showed that the group with 12cm heel showed significantly high muscle activation compared to the groups with 1cm and 7cm heels. The result of this study can be used for various perspectives from inferring and mediating problems caused by wearing high heels on different ground slopes for a long time

Key words: *Heel Height; Walking; Lower Extremities Activity*

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Received : 9 May 2011
Accepted : 15 September 2011

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INTRODUCTION

Human walking is a complicated process of coordinated movement of about 100 upper and lower skeletal muscles, joints, and nerves. It has continuous and repetitive movements to move forward which is one of the basic activities that human requires for maintaining natural and independent life(1).

Walking process includes one leg's stability, stance phase, while the other leg's moves forward, swing phase. We acquire this ability as soon as we are born and do this for one's whole life which is why it is the fruit of exercise.

Feet, the lowest body part, accept 700 tons of weight a day. Shoes supplement the function of foot when walking while absorbing the shock that foot gets from ground to protect feet .

Women's shoes these days exceed the functional side of shoes. They became the essential factor that satisfy and improve desire for beauty. Moreover, women spend longer time on high heels as women's social activity increases. However, these high heeled shoes cause abnormal posture when walking. The various problems include decreased angle of lumbar joints, change in directional fluctuation range of body center that affects posture stability, change in lumbar and lower extremities' muscle activation according to types of shoes, and change in foot pressure that affects tiredness and transformation. In addition, increase in vital dynamics load increases metabolism and energy consumption and affects breathing and heart activation which in turn causes instability of body posture not only while normal walking period but also while standing still. Higher heel height and smaller contact area of heel on ground affected more on directional fluctuation range of body center, waist muscle, and lower extremities load. Moreover, height and type of heels not only changes muscle load but also changes directional fluctuation range of body center making the walking posture unstable(2).

Therefore, this study observes changes in lower extremities activation when young women in their 20's, the major high-heeled shoes users, walk on a treadmill 3km/h at 0°, 5°, 10°, and 15° descending slope while wearing 1cm, 7cm, and 12cm heels. This study considered the reality of women walking on different slopes with their high-heeled shoes on for a long period of time.

METHODS

Subjects

This study selected 15 young women in their 20's in P area, Gyungsangbook-do, who agreed on the experiment after thorough explanation. They weighed between 40 and 50kg and the heel heights were 1cm, 7cm, and 12cm.

The subjects were 1) healthy women in their 20s, 2) without any external injuries or problem with walking, and 3) who understands the purpose of the study thoroughly. Before participating the experiment, they were explained about the process and gave voluntary agreement(Table 1).

Table 1. General characterics of subjects(n=15)

Items	M±SD
Age(years)	21.2±1.85
Weight(kg)	53.02±3.94
Height(cm)	161.06±4.90
Foot size(mm)	238.33±2.43

Measurement

Shoes

This study used 1cm heeled shoes which are stable when walking, 7cm heeled shoes which are most widely worn in everyday life, and 12cm heeled shoes which are so-called "kill-heeled shoes". The sizes of shoes were 235mm and 240mm so that the subjects could choose proper size.

Electromyogram(EMG) and treadmill

On a treadmill, the subjects were asked to walk at 3km/h speed with no slope. While walking, the subject's muscle activation was measured. Myoresearch XP Clinical edition 1.07.44(Noraxon Inc, Arozona, USA) was used to measure lower extremities activation when walking in heeled shoes.

Procedure

This study used double pad in EMG. To collect accurate data, the body part where the pad was supposed to be attached was shaved with razor and rubbed using sandpaper to remove dead skin cell and cleaned using alcohol wetted cotton. The attached parts were sides' tibialis anterior, rectus femoris, gastrocnemius, and biceps femoris that are mostly affected by high-heeled shoes. It used recording electrode and reference electrode of 4cm in diameter.

The earth electrode was attached to tibialis anterior. For rectus femoris, the electrode was attached to the point located 1.5cm apart from the middle part above anterior superior iliac spine and patella. For biceps femoris, it was attached to the point located 1.5cm apart from the middle part between ischial tuberosity and fibular head(3). For gastrocnemius, it was attached to the upper 1/3 point between the calcaneus on femur lateral epicondyle. For tibialis anterior, it was attached to the 1/3 point from tibia head. This study used Myoresearch XP Clinical edition 1.07.44(Noraxon Inc, Arozona, USA) and selected Standard EMG Analysis with rectification, filtering, and smoothing at 50~250Hz band pass filter.

The study subjects were asked to walk on a treadmill for 30 seconds at 3km/h and chose average value of the muscle activation from 15 sec to 25 sec.

Data Analysis

The collected data were processed using SPSS 12.0 for Windows. To compare the lower extremities muscle activation on 1cm, 7cm, and 12cm heeled shoes, it used one-way ANOVA and F-test. When there was significant difference in one-way ANOVA, this study used LSD as post-hoc. The significance level was .05.

RESULTS

Each Muscle Activation according to the Height of Heels

Muscle activation of tibialis anterior

In muscle activation of tibialis anterior according to the height of heels, the right tibialis anterior's muscle activation was increased as the height of heels was increased. However, it was not significant (p>.05). The left tibialis anterior's muscle activation showed no significant change as the height of heels was increased(p>.05).

Muscle activation of rectus femoris

In muscle activation of rectus femoris according to the height of heels, the right rectus femoris' muscle activation showed significant increase as the height of heels was increased(p<.05). The left rectus femoris also showed significant increase in muscle activation as the height of heels was increased(p<.05). The 12cm group showed significantly higher muscle activation compared to the 1cm group(p<.05).

Muscle activation of gastrocnemius

In muscle activation of gastrocnemius according to the height of heels, there was no significant increase in muscle activation according to the height of heels(p>.05).

Muscle activation of biceps femoris

In muscle activation of biceps femoris according to the height of heels, the right biceps femoris muscle activation was increased as the height of heels was increased. However, it was not significant(p>.05). The left biceps femoris showed significant increase in muscle activation as the height of heels was increased(p<.05). There was no significant difference according to the height of heels(p>.05).

Table 2. Muscle activation

Group		Heel height	M±SD	F	p	Post-Hoc
Tibialis anterior	Rt	1cm	17.57±5.27	2.33	.10	
		7cm	21.85±7.49			
		12cm	24.28±11.74			
	Lt	1cm	17.85±6.22	.04	.95	
		7cm	18.49±7.63			
		12cm	18.52±6.89			
Rectus femoris	Rt	1cm	6.85±3.23	5.45	.00*	1<3
		7cm	9.58±4.04			
		12cm	11.30±3.85			
	Lt	1cm	6.83±3.32	5.06	.01*	1<3
		7cm	10.35±4.28			
		12cm	11.25±4.35			
Gastrocneimus	Rt	1cm	11.25±5.56	2.38	.10	
		7cm	14.28±6.60			
		12cm	16.91±8.76			
	Lt	1cm	15.39±12.66	.52	.94	
		7cm	14.29±7.34			
		12cm	14.70±7.38			
Biceps femoris (Lateral head)	Rt	1cm	7.02±2.92	1.35	.26	
		7cm	8.67±4.32			
		12cm	9.78±6.04			
	Lt	1cm	6.33±1.91	3.13	.05*	
		7cm	8.24±2.94			
		12cm	9.17±4.20			

*P<.05
Post-Hoc, 1; 1 cm, 2; 7 cm, 3; 12 cm

DISCUSSION

In maintaining upright posture, gravity affects muscle activation. The line of gravity starts from mastoid process at temporal bone and goes vertically down to pelvis. Then, it passes the back of hip joint to the front of knee joint(4). Having the line of gravity as baseline, muscle activation increases to maintain balance when each body part moves(5). Hyun and Jung indicated that women's high-heeled shoes induce muscle fatigue, diseases, and changes in vial dynamics(6, 7). In addition, Kim studied the effect of high-heeled shoes on sensimeter change and balance on normal people in their 20's(8).

The study suggested that the group with high-heeled shoes showed decrease in sensimeter sensitivity and ability to maintain still balance. Like this, there are many studies in progress providing vital dynamical and quantitative evidences of effects of heel height on foot transformation, muscle fatigue, change in sense, and balance by measuring them in static condition. This study compared lower extremities activity according to heel height.

The result shows that tibialis anterior's muscle activity has difference between right and left. However, it increases when one wore high-heeled shoes rather than low-heeled shoes. It is somewhat similar to the study of Basmajian and Bentzon that said tibialis anterior did not participate when one was wearing high-heeled shoes(9). Moreover, gastrocnemius relieves load using adjusted ankle-sole bending for a leg to support weight softly right after heel hits the ground. This muscle induces excessive or uncontrolled bending of knee. In addition, it is induced when heel takes off the ground and reduced almost to zero when toes take off the ground(10). Stewart suggested that dynamic connection between knee and ankle while stepping produces more than normal knee joint bending(11). Therefore, it is considered that increased heel height did not affect change in muscle activity. Right before heel takes off from the ground, bending muscles on sole contributes to forward promotion of body using absorbed energy through height. However, high-heeled shoes weaken this role which induced this result.

Biceps femoris does the most muscle activity from right before to right after heel hits the ground(12). In addition, it moves to provide stable knee through simultaneousness with knee extension muscles. This study also showed increase in muscle activity according to the heel height increase which also can be considered as increase in knee stability and the role of biceps femoris. Joseph and Nightingale reported that gravity line falls in front of hip joint which increases the muscle activity of biceps femoris(13). Gradual wearing of high-heeled shoes increases bending of knee muscle so that it doesn't give sufficient knee bending and extension during swing phase. Therefore, it reduces muscle activity.

In walking motion, rectus femoris is not activated before heel hits the ground but used right before and after toes take off the ground(14). As heel height increases, muscle activity also increased. This result agrees the result of Choi that reported increased heel height moves the center of gravity to the front which in turn increases rectus femoris activity(15). Continuous increase in muscles as heel height increases which in turn causes relatively low muscle activation is considered to be the result of Golgi tendon organ's activity that reduced α-motor neurons of biceps femoris. Rectus femoris controls the size of knee bending when taking off toes. This study also considers that increased heel height improved the ability to control knee joint size which in turn increased muscle activity.

This study only observed significant change in EMG activity of rectus femoris and biceps femoris according to different heel height.

There was no significant result in tibialis anterior and gastrocnemius. Future studies should research the effect of long term high-heeled shoes wearing on body and set the length of wearing variously.

CONCLUSION

To see the changes in muscle activation of lower extremities according to the heel height, this study conducted an experiment on female university students who often wear high-heeled shoes using EMG.

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