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The Impact of Habitual Heel Wearing on Calf Muscle Tightness

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ABSTRACT

Background: High heels (HH) are widely used by females all over the world to increase their attractiveness. High heels place's the calf muscle High in shortened position. Fewer studies observed the effects of HH on calf muscle. **Objective:** This study aims to observe the impact of prolonged wearing of different heel heights on calf muscle. **Study Design:** A Cross-Sectional study. **Settings:** Data was collected from University Students. **Duration:** 4 months after acceptance of synopsis. **Methodology:** 120 university students who habitually wore shoes of different heel heights from 1cm to 10 cm for at least 1 academic year were selected for this study. Subjects were grouped according to heel heights: 1cm, 4cm, 7cm and 10cm as flat shoe group (FSG), Low Heel Group (LHG), Middle Heel Group (MHG) and High Heel Group (HHG) respectively. To measure the ankle dorsiflexion range, weight bearing lunge test was used, with extended and flexed knee to isolate the function of gastrocnemius muscle. **Results:** Overall dorsiflexion range was significantly affected by heel heights. Wearing of HH significantly decrease the dorsiflexion range as compared to flat shoe wearers. There was statistically significant difference in dorsiflexion range according to heel height($p<0.001$). **Conclusion:** HH shoes wearing for 1 year may contribute to tightness of calf muscles. **Clinical Relevance:** It is recommended that the habitual wearers of more than 5cm heel height must undergo stretching exercises in plantarflexion direction.

Keywords: Heel height, Calf muscle, Tightness, High heels.

INTRODUCTION

High heeled shoes (HHS) characterized as a foot-wear wherein the heel is higher than the fore-part, may show increase in heel far more than 10 cm. High heels (HH) often consist of a narrow toe box, a rigid heel cap and an arched plantar region, all of that interfering with natural foot motion.[1] In modern society, many females wear HH[2] considering HH as an essential part of fashionable outfit. HH thought to characterize beauty, self-assurance and elegance.[3] Among most women regardless of discomfort HH are still preferred,[4] HH wearers take more frequent and smaller steps, have less knee bend, that makes them look more attractive.[5,6]

Numerous researches have warned females who wear HHS for prolong period of time that HHS can result into the development of changes in musculoskeletal system within the kinetics and kinematics of lower extremity and trunk.[7] It was found that HH may lead to foot-pain and deformities[2] and foot pain is aggravated by walking, prolong standing and stair climbing.[8] Many studies shows that high heels are responsible for hallux valgus, deformity, plantar calluses and reduced venous function in lower extremity.[5,9] Studies have also shown that discomfort in lower extremity increases with the increase in heel height and that a heel height >3inch may cause adverse effects on the body.[10] Skeletal muscles are highly malleable tissues which could adapt both functionally and morphologically to persistent and chronic changes in mechanical loading. In humans, HH is a common condition that causes muscular tendon units (MTUs) to be shortened and place them in a shortened position. In this condition, due to increased ankle plantarflexion which is caused by heel raise imposed through HH, length of calf MTU is reduced.[11] Previous researches described that prolong use of HHS lead to increase plantarflexion[12] and results in reduced gastrocnemius and soleus extensibility and also change their activation pattern.[13,14]

In 2013, Kim *et al*, investigated the effects of HH on ankle ROM and muscle strength. He reported that HHS wearers showed increased ankle ROM on plantarflexion and inversion when compared to flat shoes(FS) wearers while reduced dorsiflexion and eversion[7] In 2016, Farrag

et al. reported the effects of HH on isokinetic performance of plantar flexors and ROM of ankle joint of habitual wearers of HH. He found that routine usage of HHS effected contractile characteristics of the soleus muscle more than the gastrocnemius muscle.[15] The recent study aimed to evaluate the effects of different heel heights on calf muscle tightness. It was hypothesized that increasing the heel height will result into increased tightness.

METHODOLOGY

Study Design: A Cross-Sectional study

Settings: Data was collected from University Students.

Duration: 4 months after acceptance of synopsis.

Sample Technique: Non-probability convenient sampling.

Sample Size: 120 subjects were divided into 4 equal groups of 30 each. Non-probability convenient sampling technique was used. Sample size was calculated by the following formula keeping the power of study equal to 90% and level of significance to 5%. Sample size should be 30 in each group.

$$n = \frac{(Z_{1-\beta} + Z_{1-\alpha/2})^2 + (\delta_1^2 + \delta_2^2)}{(\mu_1 - \mu_2)^2}$$

Desired level of Significance = α = 95%

Desired power of the study= β=90%

Mean Difference= $\mu_1 - \mu_2$ = 80.7-100.8= 20.1

Standard Deviation of Group A = δ_1 = 16.9

Standard Deviation of Group B = δ_2 = 13.4

Sample size in each group = n = 14.96

Inclusion Criteria: Only females, age limit 18-30 years, wearing high heels or flat shoes for a specific time limit, wearing high heels or flat shoes from past 1 year and wearing for more than 4 days a week were included.

Exclusion Criteria: Any previous Neuromuscular issue, males, lower extremity pain and any pathology, previous foot surgery, toe Walkers, pregnant females, fracture of L.E and congenital deformity of L.E were excluded.

Data Collection Procedure: 120 young healthy university students (age 18-30) who wore different heel heights from past 1 year, 5 to 7 hours a day, were selectively recruited and grouped according to their heel heights. The heel heights were: 1cm, 4cm, 7cm and 10cm and classified as Flat shoes group (FSG), Low heel group (LHG), Middle heel group (MHG) and High heels group (HHG) respectively. All 4 groups included 30 females in each group who had habitually worn shoes with specific heel heights (1, 4, 7 and 10cm) minimum three days a week from the last 1 year. Basic information and instructions about the procedure were given to each of the subject.

Before participating in the study, they answered a self-made questionnaire that included demographics, medical history and shoe wearing tendencies along with frequency and duration of wearing over the previous 1 year. Female university students who fulfilled the inclusion criteria of this study were asked to participate. Subjects were explained that their information will be kept confidential.

There was no significant difference in terms of age, weight, height and total period of shoes wearing among all groups. Additionally, for the past 1 year they had not regularly involved in any type of sports, athletic activity, strength training and stretching exercises. A total of 120 subjects had been recruited for this study. The Ethics Committee of The University of Lahore approved this study. All subjects were provided written, informed consent and their identities had been coded to protect their privacy.

Procedure to measure Tightness: To measure the tightness of calf muscles in habitual wearers of different heel heights weight bearing lunge test (WBLT) was used. For gastrocnemius it was measured with knee extended and for soleus dorsiflexion was measured with knee flexion using a universal goniometer.

The test was carried out by 1 investigator. Participant performed a lunge stance while standing facing a wall. The rear foot was the foot to be measured. Investigator helped the participant in positioning of her rear foot on a formerly marked line perpendicular to the wall, centered between 2nd toe and heel of foot. Participants were allowed to hold on to the wall to help them stabilize their stance. The subject fully extended the rear leg. Investigator ensured that the knee is completely extended because even mild knee flexion has a substantial impact on ankle dorsiflexion (ADF). To obtain maximal ADF, the subject was instructed to move the hip towards the wall until it was just before the heel lift off the rear leg. Participant was allowed to flex the front leg as needed. Investigator placed 1 hand on dorsal aspect of the subtalar joint to make sure a neutral supination/pronation position of the rear foot. ADF measurements were performed using goniometer. One arm of the goniometer aligned along the fibular head, other arm on the floor parallel to 5th metatarsal. Measurements were then recorded.

To measure the effects on soleus ADF was measured with knee flexed. The subject performed the weight bearing lunge stance with the rear leg flexed as comfortable and move the hip towards the wall until it was just before the heel lift of the rear leg. Investigator ensured that the rear knee was at least 20 degrees flexed. In case of uncertainty, goniometer was used to make sure that knee flexion was greater than 20 degrees. Measurement of ADF with knee flexed was then recorded. 3 measurements were taken and then mean was calculated.

ADF ≤ 10 degree has to be considered impaired. Values between 10 to 20 in weight bearing lunge have to be considered limited. If knee flexion resulted in a 10° increase in ADF then gastrocnemius tightness present. If knee flexion does not cause increase of ADF, gastrocnemius tightness is not evident. Musculus gastrocnemius tightness (MGT) characterized by

impaired ADF with extended knee. Knee flexion results in an increase of ADF.[16] The tightness was measured through weight bearing lunge test as mentioned above.

RESULTS

Data was collected by 120 females. Mean age of the subjects was 23.87±3.175 in this study. Minimum age of participant was 19 and maximum age was 30. Over all mean BMI of the participants was 25.92±5.57. [Table-1]

Table 1: Socio-demographics:

Socio-demographics	Age	Weight	Height	BMI
Mean ± S.D	23.87 ± 3.17	55.71 ± 5.23	4.84 ± 0.37	25.92 ± 5.57

There is statistically significant difference between DF-KE according to shoe types (p-value < 0.001).The difference between DF-KE of Flat shoes and Low Heels was significant(p-value <0.001).Difference in DF-KE of Flat shoes and Middle Heels was significant(p-value<0.001).Difference between DF-KE of Flat shoes and High Heels was significant (p-value<0.001).Difference between DF-KE of Low Heels and Middle Heels was significant(p-value<0.001).Difference between DF-KE of Low Heels and High Heels was significant(p-value<0.001). Difference between DF-KE of Middle Heels and High Heels was significant(p-value<0.001). [Table-2]

Table 2: Impact and comparison of different heel heights on DF-KE

DF - KE	Mean ± Std. Deviation	95% Confidence Interval for Mean		P-value
		Lower Bound	Upper Bound	
Flat Shoes	20.4833 ± 4.14080	18.9371	22.03	<0.001
Low Heels	17.4000 ± 4.83415	15.5949	19.21	
Middle Heels	9.6500 ± 0.82158	9.3432	9.96	
High Heels	10.2500 ± 1.21591	9.7960	10.70	
Total	14.4458 ± 5.65901	13.4229	15.47	

There is statistically significant difference between DF-KE according to heel height (p-value<0.001).

There is statistically significant difference in DF-KF according to shoe types (p-value<0.001). Difference between DF-KF of Flat shoes and Low Heels was significant(p-value<0.001). Difference in DF-KF of Flat shoes and Middle Heels was significant(p-value<0.001).Difference between DF-KF of Flat shoes and High Heels was significant (p-value<0.001).Difference in DF-KF of Low Heels and Middle Heels was significant (p-value<0.001).Difference between DF-KF of Low Heels and High Heels was significant(p-value<0.001). [Table-3]

Table 3: Impact and comparison of different heel heights on DF-KF

DF-KF	Mean ± Std. Deviation	95% Confidence Interval for Mean		P-value
		Lower Bound	Upper Bound	
Flat Shoes	30.3000 ± 3.07549	29.1516	31.4484	<0.001
Low Heels	26.3000 ± 5.16720	24.3705	28.2295	
Middle Heels	17.9000 ± 1.85881	17.2059	18.5941	
High Heels	18.9167 ± 2.38198	18.0272	19.8061	
Total	23.3542 ± 6.15227	22.2421	24.4662	

There is statistically significant difference between DF-KF according to heel height (p-value <0.001).

DISCUSSION

This study distinguishes the impact of different heel heights on calf muscle tightness in habitual wearers. In this study the effects in users of 4 different heel heights were compared. There were 120 participants mean age 23.87±3.175, the maximum age of the subjects was 30 years and the minimum age was 19 years. In this study it was found that increasing the heel height results in to decrease in dorsiflexion range. The decrease in dorsiflexion was maximum in HHG when compared to MHG, LHG and FSG. Thus, the HHG had the maximum tightness when compared to other groups. The observed effects could be attributed to the fact that due to prolonged use of HH tissues around ankle become stiff on posterior side

The length of calf muscles would decrease due to the plantarflexed position of ankle in heeled shoes. ROM of dorsiflexion was dichotomized in the full knee extension and at flexion because ankle dorsiflexion examination in various knee positions is useful for discriminating shortening of posterior ankle structures.

Human motion need ongoing, finely tuned interaction between muscles and tendons, so changes in properties of either tissue lead to important functional consequences and use of HH changes the functional demands placed on lower extremity MTUs.[17] The biomechanics and muscles activities are significantly changed during HH walk as compared to normal walking.[18,19] In response to chronic adaptations in mechanical load and length, human muscles and tendons exhibit variations in size and material properties.[17] Previous studies have proven that wearing HH alter normal gait and obtrude non-physiological state of muscle tissues and joints. This leads to increase metabolic cost and muscle load and can result

into acceleration of muscle fatigue.[13,17,20] Habitual HH wearers were reported to experience chronic alterations in muscle tendon architecture, which includes shortening of gastrocnemius medialis fascicles[11,17,21] and increased stiffness of the Achilles tendon.[11] These studies support recent study that due to prolonged wearing of different heels cause the changes in muscle tendon architecture and thus causing tightness.

A previous study reported that in the habitual HH wearers the calf muscle musculotendinous structural changes included shortening of gastrocnemius fascicle length and increased stiffness and of the Achilles tendon. They reported a shortening of gastrocnemius and increased Achilles tendon stiffness in HH wearers, which would possibly decrease the ankle range of motion and therefore explained the discomfort experienced by those females while walking in flat shoes. They concluded that muscle structure might adapt to a chronic alteration in functional demand.[11] Recent study agrees with this study, the prolonged use of heeled shoes put the calf MTU in a shortened position, thus reducing the ankle dorsiflexion range and causing tightness. Another study reported that habitual wearing of HH shoes decreases the dorsiflexion range when compared to FS wearers[7] which agrees with the results of present study.

None of these studies observed the effects of prolong wearing of different heel heights on dorsiflexion range. They did not specify the heel height and observed the dorsiflexion range in wearers of random heel heights. In contrast to these studies recent study have observed the effects of habitually wearing of different heel heights on dorsiflexion range in 4 different groups.

In present study WBLT was used because of its high reliability. As the body weight is used thus there is less chance of bias. Another strength of the following study was the larger sample size. Previous studies examined in a smaller group of subjects but in recent study the effects were observed in a larger group of subjects and included the participants who wore a specific heel height from a specific time period.

CONCLUSION

Wearing heels of different heights for prolong period of time leads to musculoskeletal changes in foot. This study concluded that prolong wearing of heels decrease dorsiflexion range, thus causing tightness. Tightness of calf muscle was highest in HHG as compared to FSG, LHG and HHG.

LIMITATIONS

Main limitation of the current study was boundedness of time. We did not have enough time to make this study more reliable. Other limitation is the measuring instrument, as it is an objective assessment so there may be some error while using the instruments.

SUGGESTIONS / RECOMMENDATIONS

Present study was cross-sectional study, it is recommended that individuals who wear heeled shoes of more than 5 cm must undergo intensive stretching techniques in direction of plantarflexion. It is cautiously recommended to wear high heeled shoes for less time as it causes deleterious effects on musculoskeletal system.

CONFLICT OF INTEREST / DISCLOSURE

None declared.

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