Effects of Wearing High Heels on Ankle Plantarflexion

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Highlights:

- In modern society many females wear heeled shoes. Heeled shoes affect the ankle biomechanics. Plantarflexion range of ankle also affected.
- Recent study was conducted to observe the effects of wearing different heel heights on plantarflexion range.
- Plantarflexion range does not remain same in different heel height wearers. Increase in heel height result in to increase plantarflexion range.

Abstract:

Wearing High Heels (HH) for prolong period may cause kinetics and kinematics changes of lower extremity. It may lead to musculoskeletal deformities.

Objective:

To determine the effects of wearing different high heel shoes on ankle joint plantar flexion range.

Methodology:

120 healthy university students who habitually wore shoes of different heel heights from 1cm to 10cm for at least 1 academic year, more than 5 days a week were selectively recruited. Participants were grouped according to their heel heights: flat, low, mid and high heels. Ankle plantarflexion was measured using universal goniometer in all 4 groups.

Results:

Overall plantarflexion range was significantly affected by heel height (p-value <0.001). Wearing high heels significantly increased the plantarflexion range as compared to flat shoe wearers (p-value <0.001). There was statistically significant difference in plantarflexion range according to heel height (p<0.001).

Conclusions:

Wearing high heels shoes for 1 year enhanced the plantarflexion range of motion in all heel groups and the change was most significant in HH group. Habitually wearing of high heels increases the plantarflexion range of motion in heel wearing groups but it was not seen in flat shoes group (FSG). Increase in range depends on heel height; increasing the heel height results into increase plantarflexion range.

Key Words:

High heels; Heel height; Plantarflexion ; Range of motion

Introduction:

High Heeled shoes (HHS) are characterized as a foot-wear where the heel is higher than the forefoot which may show increase in heel far more than 10 cm. Typical shoes have a heel elevation of less than 2cm.[1] High heels (HH) thought to be a symbolize splendor, self-belief and elegance[2]. HH wearers take repeated and short steps and there is increased hip rotation, that makes them look more attractive.[3,4] Surveys of shoe choice reported that 37% to 69% of females mostly used HHS.[5] American Podiatric Medical Association(APMA) found that out of 503 women 72% wore HHS often and 39% carrying them daily.[6] among 39% of American women[6,7] and 78% of British ladies were wearing them in daily routine.[7,8] A large number of ladies in Western Societies often go with wearing HH and usually without falling.[9] Although, epidemiological studies showed that nearly 60% of foot related issues in females were related with wearing of HHS.[5,10,11] Previously, it has been recommended that the prolonged use of HHS might result into harmful effects on the musculoskeletal system, which may additionally

result into chronic foot-pain and deformities.[12,13] After wearing HHS, rear foot angle becomes considerably varus and wearing HH for prolong time might result into changes into plantar arch.[3,14] As the heel increased the plantar region pressure shifted from heel and mid-foot to medial fore-foot.[3,15,16] In humans, HH is responsible for shortened position of muscle tendon units (MTUs) that is very rare situation. In this situation, calf MTU length is decreased due to ankle plantarflexion occurring when there is increase in heel height.[17] HH disturb the ankle joint's normal function and structure by placing the foot in plantar flexion position.[1] HH are also responsible for biomechanical changes that result while walking such as elevated plantar flexion and hyperextension of metatarsophalangeal joint.[18] Other changes involve plantar flexion of ankle during stance phase that result in alter the posture like hip and knee flexion.[8] Previous researches described that long term use of HHS lead to increased plantarflexion and results in reduced gastrocnemius and soleus extensibility and also change their activation pattern p-value< 0.05 when compared to low heel and without shoes group.[19,20] In 2013, Kim et al. conducted a study to evaluate the effects of HH on ankle ROM and muscle strength. He reported that HHS wearers showed increased active and passive ankle ROM on plantarflexion 25 degrees when compared to flat shoes(FS) wearers (p-value<0.05).[18] The purpose of this study was to determine the effects of different heel heights on ankle plantarflexion range. It was hypothesized that increasing the heel height will result into increased plantarflexion range.

Methodology:

The sample size was calculated by the following formula keeping the power of study equal to 90% and level of significance equal to 5%. The sample size should be 30 in each group. 120 healthy and young females average age 23.87±3.17 years (range18-30 years) who wear specific heeled shoes from past 1 year, for more than 5 days of week have participated in this study from different universities of Lahore, Pakistan. Subjects with neural and musculoskeletal system dysfunction or pain were excluded. Convenient sampling technique was used. Study was cross-sectional. Participants answered the structured questionnaire consisting of demographics, medical history and shoe wearing tendencies including frequency and duration of period over the preceding 1 year. The dominant leg was determined by asking the subjects that which leg they would be more likely to use when kicking a ball. Subjects were explained that their information will kept confidential. The subjects were sorted in 4 groups based on eligibility criteria of the heel heights outlined in another study21. The different heel heights were classified as : 1cm (Flat Shoe Group) , 4cm (Low Heel Group) , 7cm (Mid Heel Group) and 10cm (High Heels Group) and reported as flat shoes group(FSG), low heel group(LHG), mid 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. Active and passive plantarflexion ROM was measured by using Universal Goniometer. Active ROM was measured because most of the tasks performed in daily life require active ROM and Passive ROM was measured to confirm viscoelastic properties of the involved muscles. Maximal angular ranges of palntarflexion were measured. To measure the plantarflexion, subjects were asked to place their ankles over the edge of a table while lying in a supine position. Fulcurm of the goniometer was placed at lateral malleolus, stationary arm was placed along the fibular head with moving arm parallel to 5th metatarsal. Then subjects were asked to perform plantarflexion and the measurements were recorded. Passive ROM was measured by the investigator itself. All measurements were taken 3 times and then the mean was calculated. Collected data was entered and analyzed by using spss 21.

Results:

In recent study mean age of the subjects was 23.87±3.17years (range18-30years) (Table 1). Data was collected by 120 females. There is statistically significant difference between

Plantarflexion (Active and Passive) according to shoe heel height (p-value <0.001). Difference in plantar flexion (active and passive) of flat shoes with low heels, mid heels and high heels was significant. Difference in plantar flexion (active and passive) of low heels with mid heels and High Heels was significant. Difference between Plantarflexion(Active and Passive) of Mid Heels and High Heels was significant. All these associations showed (p-value< 0.001) (Table 2,3).

There is statistically significant difference between Plantar Flexion (Active) according to heel height (p-value <0.001). Comparison of different heel heights shows that as the heel height increases, active plantarflexion range also increases. Planatrflexion(Active) of (FS) group was 39.25±4.65 degrees, (LH) group was 51.1500 ±3.15996 degrees, (MH) group was 60.45±4.64 degrees and (HH) group was 57.5000±11.74514 degree which shows statistically significant difference among groups (Table 2).

There is statistically significant difference between PlantarFlexion (Passive) according to shoe heel height (p-value <0.001). Comparison of different heel heights shows that as the heel height increases , passive plantarflexion range also increases. Plantarflexion(Passive) of FS group was 45.55±5.18 degree, LH group was 56.80±3.07 degree, MH group was 67.0500±5.02640degree and the HH group was 64.07±12.57 degree, There is statistical significant difference among all 4 groups. Comparison of different heel heights shows that as the heel height increases , passive plantarflexion range also increases (Table 3).

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

Table 1: Socio-Demographics

Plantar Flexion (Active	Mean± Std. Deviation	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
Flat Shoes	39.25±4.64	37.52	40.98	<0.001
Low Heels	51.15±3.16	49.97	52.33	
Mid Heels	60.45±4.64	58.72	62.18	
High Heels	57.50±11.75	53.11	61.89	
Total	52.09±10.65	50.16	54.01	

Table 2: Impact and comparison of different heel heights on Plantar flexion (Active)

Plantar Flexion (Active	Mean± Std. Deviation	95% Confidence Interval		P-value
		Lower Bound	Upper Bound	
Flat Shoes	45.55±5.18	43.62	47.48	<0.001
Low Heels	56.80±3.07	55.65	57.95	
Mid Heels	67.05±5.03	65.17	68.93	
High Heels	64.07±12.58	59.37	68.76	
Total	58.37±11.08	56.36	60.37	

Table 3: Impact and comparison of different heel heights on plantar flexion (Passive)

Discussion:

This study distinguished the effects of different heel heights on ankle Plantarflexion range in habitual heel wearers. In this study the effects in users of 4 different heel heights were compared. In this study it was found that increasing the heel height increases the range of plantarflexion. Maximum range of motion of plantarflexion was greater in HH group as compared to FS, LH and MH groups. A previous study reported that in the habitual HH wearers the calf muscle musculotendinous structural changes in the form of gastrocnemius fascicle length shortening and increased thickness and stiffness of the Achilles tendon. They observed these findings on a sample size of 22 female participants. They found resting position of ankle more plantarflexed 11.42±1.95 in HH group while 6.32±2.38 in FS group. They concluded that muscle structure may adapt to a chronic change in functional demand.[17] 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 and increasing

the plantarflexion and inversion range. Another study reported that habitual wearing of HH shoes increases the plantarflexion range when compared to FS wearers which agrees with the results of this study. They observed active plantarflexion in Flat shoes group was 80.7±16.9 while in HHS group was 100.8±13.4 and passive plantarflexion was 88.6±22.7 in Flat shoes group while 106.8±16 was in High heel shoes group. They reported that HHS wearers showed increased active and passive ankle ROM on plantarflexion 25 degrees when compared to flat shoes(FS) wearers (p-value<0.05). They conducted their study on a small sample size of 20 participants.[18] Recent study was done on a large sample size of 120 subjects and found similar results as in the above mentioned study but here we compared 4 different heel heights groups while they only compared 2 groups. But none of these studies observed the effects of prolong wearing of 4 different heel heights on plantarflexion range. Instead they observed the plantarflexion range of specific heel heights in wearers or have compared the 2 groups. In contrast to these studies recent study have observed the effects of habitually wearing of different heel heights on plantarflexion range in 4 different groups. Another, strength of the following study is 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. By placing the foot in plantarflexion position, increases the risk of anterior ligament tear as there is lengthening of ligament for prolong period of time. It is recommended that the habitual wearers of more than 5cm heel height must undergo stretching exercises in dorsiflexion direction and strengthening exercises in plantarflexion direction.

Conclusions:

Wearing of HH shoes for 1 year may contribute to enhancing the plantarflexion range of motion in all heel groups and the change was most significant in HH group. Habitually wearing of high heels increases the plantarflexion range of motion in heel wearing groups but it was not seen in FSG. Increase in range depends on heel height; increasing the heel height results into increase plantarflexion range.

References:

01- Cronin NJ. The effects of high heeled shoes on female gait: a review. Journal of electromyography and kinesiology. 2014;24(2):258-63.

02- Gerber SB, Costa RV, Grecco LAC, Pasini H, Marconi NF, Oliveira CS. Interference of high-heeled shoes in static balance among young women. Human movement science. 2012;31(5):1247-52.

03- Ran M, Hao F, Yang L, Wu S. Effects of High Heels on Centre of Pressure Progression During Walking In Young Women Influenþa Pantofilor Cu Toc Înalt Asupra Progresiei Centrului De Presiune În Timpul Mersului La Femeile Tinere. Revista de Pielarie Incaltaminte. 2016;16:1.

04- Morris PH, White J, Morrison ER, Fisher K. High heels as supernormal stimuli: How wearing high heels affects judgements of female attractiveness. Evolution and Human Behavior. 2013;34(3):176-81.

05- Hong W-H, Lee Y-H, Lin Y-H, Tang SF, Chen H-C. Effect of shoe heel height and total-contact insert on muscle loading and foot stability while walking. Foot & ankle international. 2013;34(2):273-81.

06- Yoon J-Y, An D-H, Yoo W-G, Kwon Y-R. Differences in activities of the lower extremity muscles with and without heel contact during stair ascent by young women wearing high-heeled shoes. Journal of Orthopaedic Science. 2009;14(4):418-22.

07- Chien H-L, Lu T-W, Liu M-W. Effects of long-term wearing of high-heeled shoes on the control of the body's center of mass motion in relation to the center of pressure during walking. Gait & posture. 2014;39(4):1045-50.

08- Curran SA, Holliday JL, Watkeys L. Influence of High Heeled Footwear and Prefabricated Foot Orthoses on Energy Efficiency in Ambulation. Podiatry Review. 2010;67(3).

09- Alkjær T, Raffalt P, Petersen NC, Simonsen EB. Movement behavior of high-heeled walking: how does the nervous system control the ankle joint during an unstable walking condition? PloS one. 2012;7(5):e37390.

10- Cho N, Kim S, Kwon D-J, Kim H. The prevalence of hallux valgus and its association with foot pain and function in a rural Korean community. Bone & Joint Journal. 2009;91(4):494-8.

11- Dawson J, Thorogood M, Marks SA, Juszczak E, Dodd C, Lavis G, et al. The prevalence of foot problems in older women: a cause for concern. Journal of Public Health. 2002;24(2):77-84.

12- Mika A, Oleksy L, Mika P, Marchewka A, Clark BC. The effect of walking in high-and low-heeled shoes on erector spinae activity and pelvis kinematics during gait. American journal of physical medicine & rehabilitation. 2012;91(5):425-34.

13- Yu J, Cheung JT-M, Fan Y, Zhang Y, Leung AK-L, Zhang M. Development of a finite element model of female foot for high-heeled shoe design. Clinical Biomechanics. 2008;23:S31-S8.

14- Pezzan PA, Sacco IC, João S. Foot posture and classification of the plantar arch among adolescent wearers and non-wearers of high-heeled shoes. Brazilian Journal of Physical Therapy. 2009;13(5):398-404.

15- Speksnijder CM, vd Munckhof RJ, Moonen SA, Walenkamp GH. The higher the heel the higher the forefoot-pressure in ten healthy women. The foot. 2005;15(1):17-21.

16- Zhou J, Zhang W, Xu B, Chen W. Effect of Arch Support on The Insole Pressure Distribution of Heel Heighted Shoes Efectul Suportului Plantar Asupra Distribuþiei Presiunii La Pantofii Cu Toc Înalt. Revista de Pielarie Incaltaminte. 2012;12:4.

17- Csapo R, Maganaris C, Seynnes O, Narici M. On muscle, tendon and high heels. Journal of Experimental Biology. 2010;213(15):2582-8.

18- Kim Y, Lim J-M, Yoon B. Changes in ankle range of motion and muscle strength in habitual wearers of high-heeled shoes. Foot & ankle international. 2013;34(3):414-9.

19- Mika A, Oleksy Ł, Mika P, Marchewka A, Clark BC. The influence of heel height on lower extremity kinematics and leg muscle activity during gait in young and middle-aged women. Gait & posture. 2012;35(4):677-80.

20- Candotti CT, Carvalho Kd, La Torre M, Noll M, Varela M. Ativação e co-contração dos músculos gastrocnêmio e tibial anterior na marcha de mulheres utilizando diferentes alturas de saltos. Rev Bras Cienc Esporte. 2012;34(1):27-39.