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Does Prolonged High Heeled Footwear Impacts Foot Biomechanics in Fashion Industry

Shivani Jain
Assistant Professor, Krupanidhi College of Physiotherapy, 12/1. Chikkabellandur, Carmelaram Post, Bangalore-560035
Email: shivani.jainphysio@gmail.com

ABSTRACT
Heel pain is a popular deleterious effect on the foot and ankle. High-heeled footwear leads to various foot problems. Such footwears worn for a long period of time causes foot dysfunctions including hallux valgus, heel pain and toe deformities. Thus, there is the need to analyse the impact of prolonged use of high-heeled footwear on the static foot alignment when compared to those, not wearing high-heeled footwear. A total of 152 subjects were taken from the fashion industry across Bangalore and were equally assigned into study and control group. Subjects included in the study group were females wearing high heeled footwear and the control group included subjects wearing flat footwear. The static foot angles measured were the hindfoot angle, the forefoot angle and the navicular drop for both the foot. Student t (two tailed, independent) test has been calculated to find the variation in the study parameters between the two groups. Effect size due to Cohen has been used to find the effect of footwear's with high-heels on the studied characteristics. When compared with control group, the study group showed greater static angles, viz. subtalar neutral in non-weight bearing, subtalar neutral in weight bearing, forefoot angle, hindfoot angleand navicular drop. Inference of the study showed the prolonged use of high heeled footwear to have an impact over the static foot angles thereby affecting the foot biomechanics leading to dysfunctions.
KEY WORDS: *High-heel footwear, Subtalar neutral, Navicular drop, Fore-foot angle, Hind-foot angle*

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INTRODUCTION

Prehistoric Mid-western people are thought to have constructed a long array of shoe during the early period of 8300 calendar years from today in central Missouri which is supported by many other archaeological evidences but unfortunately these initial foot wears were considered very basic [1, 2]. The common use of narrow footwears with firm heel cups, support for the foot arch and heel cushion, or shoes with motion control came much later [3]. Another modification done in this basic footwear design was the use of high heel [3].Footwears with h***igh-heel*** were first seen in Persian cavalry to help them keep their ***shoes*** fit snuggly in their stirrups as early as in the 10thcentury [4]. Interestingly, this fashion intrigued the women and in Northern Europe, women began to wear heels too, which got further slimmed down and the foot bed of the shoe began to lower that was certainly more attractive than those of the past5. High-heeled footwear are found to significantly influence the attractiveness of the females.6Experimental studies have shown that heels exaggerate the secondary sexual traits of a woman with the exaggeration of prototypical women's gait [7].

This is not the only reason for females to wear high heel footwear. The other reasons for the same were found to be special occasions such as weddings, parties, shopping, professional attire, fashion or style and even to appear taller [8]. High heels for women have been associated with the occasions and fashion to an extent that they have become mandatory attire in certain profession and also some social events [1, 9]. Fashion industry is one such profession where high heeled footwear is the basic requirement to excel in the field [10]. Over the years, the global medical fraternity had correlated various musculoskeletal problems to the usage of high heeled footwear [10].A conventional footwear with a forefoot slope (i.e., heel height of 50 mm)is beneficial as it provides a less propulsive force at heel-off to toe-off phase of the gait cycle to maintain a set walking speed [11].

Corrigan et al explained that high heeled footwear increases pressure on the metatarsal heads especially of the 1st metatarsal bone, thus stressing the front of the foot along with the changes in the foot loading pattern which was found to be more with the heel height of 4cms when compared to the heel height of 2 cms [12]. Thus, the former results in bunion, heel pain, hallux valgus, shortened tendoachillis leading to weakness and decreased range at the ankle [13, 14]. Another study done by Emma Cowley et al, stated that the design of high heels shoes causes the pathologies by crushing the forefoot and reducing midfoot support [15]. Increase in the heel height, also adds up to the forefoot loading and reduces the same on the hindfoot, due to the obvious plantar flexion, thus a higher load on the medial forefoot increases the debilitation due to hallux valgus deformity [16]. Dewi et al in 2019 also inferred that the high heel footwear maximizes the pressure on the fore foot mainly at the metatarsal heads, thereby contributing for the deleterious orthopedic changes of the foot [17]. It has been seen that as the heel height increases, the plantar flexion in the foot also goes on increasing [18].This shows a drastic change in the Centre of pressure and other parameters- single support line, length of the gait line, and anteroposterior forces of the foot along with a significant difference in the plantar pressure distribution on the 1stmetatarsal and middle forefoot area and reduced pressure in the middle foot thereby increasing the anterior shift [19, 20].

Biomechanically, the use of high heel along with the foot and ankle complex also has an associated impact on other body mechanics as studied recently by Jency Thangasheela G (2021), who identified a vast change in the gait and posture especially of the lumbar region such as reduced length of the stride and the step, reduced velocity, increase in the base width, increased lumbar lordosis and also increase in the cadence [21]. Another survey done on women(200 subjects) using high heeled footwear regularly with the heel height between 6 cm-9 cm, it was noted that approximately half of the subjects complained of backache with limitations in their daily activities [22]. These variations in gait and posture can be attributed to the knee mechanics observed by Mika A in 2012, that the knee flexion and the ankle eversion increased and decreased respectively with increased heel height indicating that the compensatory mechanisms enhancing the ground reaction forces may be compromised during high heeled gait.16 Also, such gait increased the activity of Tibialis Anterior and Rectus Femur is muscles thereby inducing muscle fatigue [16].

Use of high heeled footwear causes excess of plantar flexion in the foot which is expected to bring about some changes in the foot biomechanics. The biomechanical alterations, it has on the foot is not studied extensively. There is a dearth of the evidences for the biomechanical changes in the foot, in individuals wearing high-heeled footwear as compared to the subjects wearing flat footwear. The novelty of the study is to explore the changes in Subtalar Neutral, Forefoot Angle, Hind foot Angle and Navicular Drop amongst the population wearing high heeled footwear comparing to the population wearing flatfoot wear, so that the physiotherapist can take appropriate measures to intervene with the changes if obtained.

MATERIAL AND METHODS

The type of this study is a cross-sectional study with two groups where 172 subjects were taken based on convenience method of sampling, group I were the subjects wearing flat footwears and group II were the subjects wearing high heeled footwear. After obtaining the IEC Approval, the study was explained to the subjects and the informed consents were taken. The source of group I was the modeling agencies in Bangalore with 76 subjects and group II included 76 college students from fashion schools across Bangalore. The duration of the study was Feb 2022 to July 2022. The inclusion criteria were females with 18 to 24 years of age. Study group (Group II) included fashion models wearing footwears with heel height of more than or equal to 2 inches [23] for more than 1 year, for 7 hrs a day minimum 5days in a week. Control group included the students wearing flat footwear only. The exclusion criteria were the subjects with congenital deformity, history of any foot surgery, any traumatic injury of the lower limb, painful foot, neuropathic conditions of the lower extremities and expecting mothers.

PROCEDURE

Based on the inclusion criteria, the subjects were selected. All the subjects got their foot angles measured and an average of three readings were taken for the navicular drop, forefoot angle and the hindfoot angle.

MEASUREMENT OF THE STATIC FOOT ALIGNMENT

In Non- weight bearing (NWB), Subtalar Neutral (STN) and Forefoot angle (FFA) were measured.

A) Subtalar neutral position [24]

Subjects were positioned in prone lying with one leg in 90 degrees of knee flexion and externally rotated with the ankle resting on the other leg which is extended at the knee. A line dividing the calcaneus and another line bisecting the extended leg at the lower one third was drawn till the mid heel of the extended leg. These two lines formed an angle which was measured using goniometer.

B) Forefoot angle [25]

The reference point used here was the Subtalar neutral in non-weight bearing. Therapist maintained the subtalar joint in neutral position. Goniometer was used to measure the angle formed by the imaginary line passing through the metatarsals head (movable arm) and the perpendicular of the calcaneal bisection (stationary arm).Forefoot varus was marked as positive degree, neutral as zero degree and valgus as negative degree.

Weight bearing (WB) position was used to measure the Subtalar Neutral (STN) and the Hindfoot angle (HFA)

A) Neutral subtalar joint position [25]

Subjects stood on a 25 cms high wooden block for easy measurements. Subtalar joint was palpated for the neutral position. The foot template was marked on the block to ensure the reliability of measurements. In this position, subtalar neutral angle was measured using the goniometer, as the angle formed by the line bisecting the lower one-third of the leg and another line bisecting the calcaneus.

B) Hindfoot angle [25]

Hindfoot angle was measured in single leg standing by asking the subjects to flex the opposite knee and take the support of the rails for balance. Subjects were placed in their foot template and immovable arm of the goniometer was placed parallel to the ground and the movable arm perpendicular to it. Hindfoot varus / valgus was measured by aligning the movable arm with the line bisecting the calcaneum.

C) Measurement of navicular drop (ND)-Brody's technique [25]

The reference point for the measurement of navicular drop was subtalar joint neutral position. The subjects were made to stand in relaxed standing in their foot template to palpate the navicular bone on the medial aspect of the midfoot andthe most prominent point of the bone was marked. The level of navicular bone was measured by vertically placing a setsquare along the medial aspect of the foot. Each subject then liftedone foot and navicular level was measured again in the same way but this time in the relaxed unilateral stance. The difference between the two readings was taken as navicular drop.

Statistical Analysis

Student t (two tailed, independent) test had been used to find the significance of study parameters between the groups. Effect size due to Cohen had been used to find the impact of high-heeled shoes on the study parameters. SPSS 29.0 was used for statistical analysis

RESULTS

The baseline parameters of the two groups i.e., height, age, weight and Body Mass Index (BMI) was compared to find homogeneity of the groups studied using inferential statistics.

Table 1: Demographic data

Basic characteristics	Control group Mean ± SD	Study group Mean ± SD
Age (years)	24.93 ± 2.53	24.86 ± 2.49
BMI (kg/m^2)	21.36 ± 1.27	19.89 ± 0.97
No. of subjects	75	75

The above table indicates the age and BMI of the two groups.

Table 2: Comparison of study parameters among the control group and the experimental group in the dominant foot

Study parameters	Control Growp Mean ± SD	Study Group Mean ± SD	P Value	Effect Size
STN (NWB) (degree)	0.23±3.94	-11.44±3.34	0.001	3.18 (VL)
FFA (degree)	2.82+3.49	7.42±1.40	0.001	1.72 (VL)
STN (WB) (degree)	-3.75±0.78	-9.22+3.06	0.001	2.44 (VL)
HFA (degree)	-4.19±1.01	-9.40+2.83	0.001	2.44 (VL)
ND (mm)	1.96±0.40	4.46±1.29	0.001	2.60 (VL)

The above table indicates the P value with its significance and effect size of all the studied parameters in the both the groups where the mean Negative value signifies valgus, mean Positive value signifies varus and mean zero signifies neutral position of the foot.

Table 3: Comparison of study parameters between the control group and the study group in the non-dominant foot

Study parameters	Control Group Mean±SD	Study group Mean±SD	P value	Effect size
STN (NWB) (degree)	0.06±4.02	-10.86±3.47	0.001	2.89 (VL)
FFA (degree)	2.63±3.21	7.26±1.41	0.001	1.86 (VL)
STN (WB) (degree)	-4.16±0.83	-9.26±2.67	0.001	2.57 (VL)
HFA (degree)	-3.63±1.16	-9.29±2.95	0.001	2.51 (VL)
ND (mm)	1.93±0.54	4.43±1.10	0.001	2.87 (VL)

The above table indicates the P value with its significance and effect size of all the studied parameters in the both the groups where the mean Negative value signifies valgus, mean Positive value signifies varus and mean zero signifies neutral position of the foot.

Table 4: Comparison of the study parameters between the dominant and the non-dominant foot of control group

Study parameters of Control	Dominant side Mean±SD	Non-dominant side Mean±SD	P value
STN(NWB) (degree)	0.23±3.94	0.06±4.02	0.191
FFA (degree)	2.82±3.49	2.63±3.21	0.204
STN (WB) (degree)	-3.75±0.78	-4.16±0.83	0.001**
HFA (degree)	4.19±1.01	-3.63±1.16	0.001**
ND (mm)	1.96±0.40	1.93±0.54	0.762

The above table indicates the P value with its significance of all the studied parameters in the both the foot in the control group where the mean Negative value signifies valgus, mean Positive value signifies varus and mean zero signifies neutral position of the foot.

Table 5: Comparison of the study parameters between the dominant and the non-dominant foot of study group

Study parameters of study group	Dominant side Mean ± SD	Non-dominant side Mean ± SD	P value
STN (NWB) (degree)	-11.4 ±3.34	-10.86±3.47	0.014
FFA (degree)	7.42±1.40	7.26±1.41	0.235
STN (WB) (degree)	-9.22±3.06	-9.26±2.67	0.861
HFA (degree)	-9.40+2.83	-9.29±2.95	0.618
ND (mm)	4.46±1.29	4.43±1.10	0.791

The above table indicates the P value with its significance of all the studied parameters in the both the foot in the study group where the mean Negative value signifies valgus, mean Positive value signifies varus and mean zero signifies neutral position of the foot.

The baseline parameters studied were age (yrs) and BMI (kg/m sq). The control group had the mean age of 24.93± 2.53 whereas study group had 24.86± 2.49 as the mean age. The BMI of the control and the study group were 21.36± 1.27 and 19.89± 0.97 respectively. All the subjects had their right foot as the dominant foot. So, both the groups were comparable.

In non-weight bearing, the subtalar neutral was in valgus, in the study group (right-11.44±3.34, left-10.86±3.47) whereas it was in varus in the control group (right 0.23±3.94, left 0.06±4.02). Comparison of the forefoot angle, in the experimental and the control group revealed that both the groups had forefoot in varus, but the study group had greater varus angle (right 7.42±1.40, left 7.26±1.41) than the control group (right 2.82±3.49, left 2.63±3.21). Also, the subtalar neutral in weight bearing, for both the groups was in valgus, with study group having the greater valgus angle (right -9.22±3.06, left -9.26±2.67) than the control group (right -3.75±0.78, left -4.16±0.83). Results showed that even the hindfoot angle in the study group (right -9.40±2.83, left -9.29±2.95) was higher than control group (right -4.19±1.01, left -3.63±1.16), with both the groups having the hindfoot into valgus. Navicular drop also was higher in the study group (right 4.46±1.29, left 4.43±1.10) when compared to the control group (right 1.96±0.40, left 1.93±0.54). Thus, suggestive of the study group havinglarger pronated foot than the control group. (Table 2 and Table 3). All the parameters showed a very large effect size with P value <0.001, in the dominant and the non-dominant foot, which is found to be highly significant.

The study parameters within the group were also compared i.e., within the control group and the experimental group. The comparison of all the parameters of the dominant and non-dominant side, in the control group (Table 4), showed that only the subtalar neutral in weight bearing and the hindfoot had a statistically significant difference. All the others viz, subtalar neutral in non-weight bearing, forefoot angle and the navicular drop had no statistically significant difference. In the study group (Table 5), only the subtalar neutral in non-weight bearing, showed statistically significant difference in dominant and non-dominant foot, with a higher mean value of the dominant side.

Resultsof control group in Table 4 show that in non-weight bearing, the subtalar neutral was in varus, bilaterally. The mean was more in the dominant foot (0.23±3.94) when compared to the non-dominant foot (0.06±4.02). Similarly, the forefoot was in varus with dominant foot having a greater mean (2.82±3.49) than the non-dominant (2.63±3.21). But the subtalar neutral in weight bearing was found to be in valgus in both the legs. Dominant foot had mean value of -3.75±0.78 whereas non-dominant foot had mean value of 4.16±0.83. This implies that non-dominant foot had a greater mean value than the dominant. Also, the hindfoot angle in both the legs were in valgus, with dominant side (-4.19±1.01) having more angle than non-dominant (mean -3.63±1.16). The navicular drop, which is the measure of foot pronation was slightly more in the dominant foot (mean 1.96±0.40) when compared to the non-dominant foot (mean 1.93±0.54).

Unlike the control group in the study group (Table 5), the subtalar neutral in non-weight bearing was found to be in valgus with mean for the dominant foot being (-11.44±3.34) and that of non-dominant foot being (-10.86±3.47). But the forefoot was in varus with not much difference in both the legs (dominant 7.42 ±1.40 and non-dominant 7.26 ±1.41). Besides, the subtalar neutral in weight bearing was in valgus, bilaterally. Right foot had the mean angle of - 9.22 ±3.06 but the left foot had mean value of -9.26 ±2.67 (left more than right). The right hindfoot (mean -9.40±2.83) had a slightly greater valgus angle than the left (mean - 9.29 ±2.95). Pronation did not show much difference in both the foot, as right foot navicular drop was 4.46 ±1.29, and left navicular drop had mean value of 4.43 ±1.10.

DISCUSSION

High-heeled footwear usage cause the structural and functional changes in the foot biomechanics[26] involving the ankle and foot structure which further impacts the foot posture and balance.[27]This studyevaluatedthe static foot angles, viz. subtalar neutral in weight and non-weight bearing, forefoot angle, hindfoot angle and navicular drop in the women wearing high heeled footwear regularly for long time and the females wearing flat shoes.

The wearing of high heel footwear maximizes the pressure under the head of the metatarsals in the forefoot, thereby contributing to the deleterious orthopedic changes of the foot [28].

This study was aimed to study any biomechanical variations in the foot due to the prolonged wearing of high heel footwear. The results between the two groups were not different significantly in both the dominant and the non-dominant foot.

In the dominant foot, there was a significant difference in the subtalar neutral in weight bearing between the study group and the control group indicating more valgus in the study group.The subtalar neutral in non-weight bearing was also statistically significant in both the groups with the study group in valgus and the control group in varus. Significant difference was also noted in the forefoot angle suggestive of increased varus in the experimental group when it was compared to the group wearing flat shoes. Statistically significant difference was observed in the hindfoot angles in both the groups showing greater valgus in the study group. The navicular drop was also significantly different in both the groups indicative of more pronated foot in the females wearing high heels than the control group.

On analysing the results of the non-dominant foot, a significant difference was observed in the subtalar neutral in weight bearing with study group having more valgus than the flat shoe group. Also, a significant difference was noted in the subtalar neutral in non-weight bearing, forefoot angle and hindfoot angle indicating the increased angles of the valgus, varus and valgus respectively, in study group against control group. The navicular drop in the two groups showed a significant difference suggesting more pronation in the study group than the control group.

On assessing the dominant (right) and non-dominant (left) foot in the control group, results revealed that the subtalar neutral in weight bearing and non weight bearing had a statistically significant difference with dominant foot being in more valgus than the non-dominant foot. The other angles of forefoot, hindfoot and navicular drop were found to be statistically significant with greater varus, valgus and pronation respectively, in the control group.

Results have also shown that the dominant and non-dominant foot ofthe experimental group, had a significant difference in the subtalar neutral in both weight bearing and non-weight bearing with both the angles having large degree of valgus in the dominant foot. A significant difference was seen in the dominant and non-dominant foot where the hindfoot was in more valgus, forefoot in more varus and also, the navicular drop was increased in the dominant foot, which is suggestive of increased foot pronation.

Our study results were favoured by study conducted by Dewi S Soemarko *et al* in 2019, which concluded that the possibility of developing haullix valgus in subjects wearing high heels is 2.6 times higher than the subjects wearing flat shoes [28]. Another study conducted in 2018 by Wang M et al found that although there was no significant differences in the abduction of the forefoot between the subjects wearing high heels and those barefoot, there was a significant difference in the forefoot adduction with high heel subjects having greater forefoot adduction (16.15∘± 1.37∘ VS 13.18∘± 0.79∘; P< 0.001).The hindfoot angles showed more dorsiflexion (16.59∘± 1.69∘ VS 12.08∘± 0.9∘; P< 0.001), increased internal rotation (16.72∘± 0.48∘ VS 7.97∘± 0.55∘; P< 0.001), with reduction in the peak hindfoot external rotation (-5.49∘± 0.69∘ VS -10.73∘± 0.42∘; P= 0.001) [28].

Foster A *et al* in 2012 compared the peak inversion angle between two groups. One with high heel of 9.5cms and other group wore the low heel with 1.5 cms height. The peak inversion angle was found to be significantly greater in the high heel footwears compared to the low heel footwear users (9.1 degrees versus 3.1 degrees; p <0.001) [29]. Owen et al in 2019 concluded a significant difference in the foot

kinematics as the height of the footwear heel changes, F(6,52)=8.182, p=0.000; Pillai's Trace=0.971; partial eta squared=0.486. Also, the actual foot segment angle during stance phase increases with increase in the heel height [30].
Significant correlations were also found by Ewa *et al* in 2019, among the type of footwear and hallux valgus (P=0.000). Interestingly, varus deformity was found to be less significant in the fifth toe (p=0.015 on left and 0.013 on right) concluding that females wearing footwears with high heel had high incidence of hallux valgus and varus deformity in the toes [31].
This may be explained in light of normal foot biomechanics, according to which, when talus is in plantar flexion (and adduction), there is calcaneal eversion. High-heeled footwear put the foot into excess of plantar flexion. This excess of plantar flexion of the talus in weight bearing could be compensated at the hindfoot by the excess of calcaneal eversion and this in turn could lead to an increased foot pronation at the midfoot (increased navicular drop).Again, it is known biomechanically that in non-weight bearing, foot supination includes, calcaneal inversion/ varus, adduction and plantar flexion, whereas foot pronation includes, calcaneal eversion/ valgus, abduction and dorsiflexion. As stated earlier, the high-heeled footwear puts the foot in excess of plantarflexion, thus prolonged use of such footwear may cause the shortening of the tendoachillis, thereby putting the foot into plantarflexion and hence limiting the dorsiflexion of the talus [27, 32]. It could be drawn that this increased plantar flexion of the talus could increase the calcaneal dorsiflexion in non-weight bearing, thus increasing the calcaneal eversion. This excess of calcaneal eversion may be compensated at the forefoot by increase in the forefoot varus/inversion. Thus, the increase in the forefoot varus in the females wearing high-heeled footwear can be attributed to the increase found in calcaneal eversion or hind foot valgus.

LIMITATIONS and SUGGESTIONS

The lumbar, pelvic, hip and knee alignment were not taken into consideration. Structural deformities of the foot and ankle were also not considered. Future studies should be conducted to study the effect of high-heeled footwear on thedynamic foot alignment.

CONCLUSION

It is concluded from this study that there is a huge impact of heel height of the footwear on the midfoot, forefoot and hindfoot angles in both the dominant and the non-dominant foot thereby impacting the structural and functional biomechanics of the ankle-foot complex.

REFERENCES

1. Trinkaus, E. (2005). Anatomical evidence for the antiquity of human footwear use. *Journal of Archaeological Science*, *32*(10), 1515-1526.
2. Kuttruff, J. T., DeHart, S. G., & O'Brien, M. J. (1998). 7500 years of prehistoric footwear from Arnold Research Cave, Missouri. *Science*, *281*(5373), 72-75.
3. Bossan, M. J. (2012). *The art of the shoe*. Parkstone International.
4. https://artsandculture.google.com/story/the-high-life-a-history-of-men-in-heels/iQJCgMgwSKV5Kw.Accessed on 11th March2022
5. https://burjushoes.com/blog/the-history-of-high-heels-10-facts-that-surprise-you/
6. Guéguen, N. (2015). RETRACTED ARTICLE: High Heels Increase Women's Attractiveness. *Archives of sexual behavior*, *44*(8), 2227-2235.
7. Barnish, M. S., & Barnish, J. (2016). High-heeled shoes and musculoskeletal injuries: a narrative systematic review. *BMJ open*, *6*(1), e010053.
8. College of Podiatry. TUC congress 2009 motion—high heels. 2009. http://www.scpod.org/news/press-release-archive/news-coverage-tuc-motion-on-high-heels/ Accessed on 23rd March 2022
9. Bunbury S. Cannes Film Festival's 'high-heels only' red carpet policy draws ire from stars. Sydney Morning Herald, 20 May 2015. https://www.smh.com.au/entertainment/movies/cannes-film-festivals-highheels-only-red-carpet-policy-draws-ire-from-stars-20150520-gh5f5d.html. Accessed on 4th Feb 2022
10. Barnish, M., Morgan, H. M., & Barnish, J. (2018). The 2016 HIGh Heels: Health effects And psychosexual BenefITS (HIGH HABITS) study: systematic review of reviews and additional primary studies. *BMC Public Health*, *18*(1), 1-13.
11. Zhang, X., Paquette, M. R., & Zhang, S. (2013). A comparison of gait biomechanics of flip-flops, sandals, barefoot and shoes. *Journal of foot and ankle research*, *6*(1), 1-8.
12. Corrigan, J. P., Moore, D. P., & Stephens, M. M. (1993). Effect of heel height on forefoot loading. *Foot & ankle*, *14*(3), 148-152.
13. Kuhn, J., & Alvi, F. (2020). Hallux Valgus.
14. Pannell, S. L. (2012). The postural and biomechanical effects of high heel shoes: A literature review. *Journal of Vascular Surgery*.
15. Cowley, E. E., Chevalier, T. L., & Chockalingam, N. (2009). The effect of heel height on gait and posture: a review of the literature. *Journal of the American Podiatric Medical Association*, *99*(6), 512-518.

16. Mika, A., Oleksy, L., Mika, P., Marchewka, A., & Clark, B. C. (2012). The influence of heel height on lower extremity kinematics and leg muscle activity during gait in young and middle-aged women. *Gait & posture*, *35*(4), 677-680.
17. Soemarko, D. S., Rahmasari, F., Kamal, A. F., Cahayadi, S. D., & Herqutanto (2019). Hallux valgus among sales promotion women wearing high heels in a department store. *Journal of orthopaedic surgery (Hong Kong)*, *27*(1), 2309499019828456. https://doi.org/10.1177/2309499019828456
18. Wiedemeijer, M. M., & Otten, E. (2018). Effects of high heeled shoes on gait. A review. *Gait & posture*, *61*, 423–430. https://doi.org/10.1016/j.gaitpost.2018.01.036
19. Shang, J., Geng, X., Wang, C., Chen, L., Zhang, C., Huang, J., Wang, X., Yan, A., & Ma, X. (2020). Influences of high-heeled shoe parameters on gait cycle, center of pressure trajectory, and plantar pressure in young females during treadmill walking. *Journal of orthopaedic surgery (Hong Kong)*, *28*(2):1-9. https://doi.org/10.1177 /2309499020921978
20. Caroline M. Speksnijder; Rieny J.H. vd Munckhof; Sjors A.F.C.M. Moonen; Geert H.I.M. Walenkamp (2005). The higher the heel the higher the forefoot-pressure in ten healthy women,*The Foot*.2005;15(1): 17–21. https://doi:10.1016/j.foot.2004.10.001
21. Jency Thangasheela G, Macklin Abraham Navamani J, swathi.S.(2021) A Study on Impact of High Heels on Gait Parameters and Postural Deviations of Lumbar Region in Young Adult Females. IOSR Journal of Pharmacy And Biological Sciences (IOSR-JPBS).,16(3):11-1
22. Lee C-M, Jeong E-H, Freivalds A. Biomechanical effects of wearing high-heeled shoes. Int J Ind Ergon. 2001; **28**:321–326.
23. El-Shafei, M. A., Yousef, A. M., Hamada, H. A., Mohamed, M. F., Al-Shenqiti, A. M., Koura, G. M., & López Sánchez, G. F. (2021). Effect of Low Versus High-Heeled Footwear on Spinopelvic Alignment at Different Phases of Menstrual Cycle in Young Adult Women: A Biopsychosocial Perspective. *Frontiers in Psychology*, 5328.
24. David J Magee (2002), Orthopedic Physical Assessment. 4th edition. Saunders, pg 765-845
25. Buchanan, K. R., & Davis, I. (2005). The relationship between forefoot, midfoot, and rearfoot static alignment in pain-free individuals. *Journal of Orthopaedic & Sports Physical Therapy*, *35*(9), 559-566.
26. Ozandaç Polat, S., & Yucel, A. H. (2018). Wearing high-heeled shoes increases the foot arch angle inducing measurable changes in the musculoskeletal system. *Journal of Back and Musculoskeletal Rehabilitation*, *31*(6), 1119-1129.
27. Dattani, N., & Dasgupta, B. (2005). Physiological impact of heeled footwear. *International Interdisciplinary Research Journal*, *2*, 101-6.
28. Wang, M., Gu, Y., & Baker, J. S. (2018). Analysis of foot kinematics wearing high heels using the Oxford foot model. *Technology and health care*, *26*(5), 815-823.
29. Foster, A., Blanchette, M. G., Chou, Y. C., & Powers, C. M. (2012). The influence of heel height on frontal plane ankle biomechanics: implications for lateral ankle sprains. *Foot & ankle international*, *33*(1), 64-69.
30. Owen, E., Fatone, S., & Hansen, A. (2018). Effect of walking in footwear with varying heel sole differentials on shank and foot segment kinematics. *Prosthetics and orthotics international*, *42*(4), 394-401.
31. Puszczalowska-Lizis, E., Dąbrowiecki, D., Jandziś, S., & Żak, M. (2019). Foot deformities in women are associated with wearing high-heeled shoes. *Medical science monitor: international medical journal of experimental and clinical research*, *25*, 7746.
32. Cynthia Norkins (2011), Joint Structure and Function, Jaypee Publications, pg 443-477

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