Influence of Wearing High Heel on Different Foot Angels in Normal Female Subjects

Amir Nazih Wadee*
*Ph. D. P. T in Department of Basic Science for Physical Therapy, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Background: Foot posture and pressure on the ball of the foot altered by wearing high heel. Its repeated wear is known to strain the hips and knees as well as increasing the risk of conditions such as osteoarthritis, hammer toe, back problems, bunions and corns. Purpose: To investigate the influence of wearing high heel on different foot angels in normal female subjects. Subjects: Thirty normal female subjects their age ranged from 18-25 years old; they were volunteers. Method: Subjects already wearing high heel (two inch) for at least eight weeks. Plain loaded X-ray on the foot to be examined was performed. Four angles were measured: Meary's, calcaneal pitch, Talonavicular coverage and lateral talocalcaneal angles. Results: There were three angles were mostly affected and had marked flat foot as follows; Meary's angle [28/30 (93.33%)], calcaneal pitch angle [27/30 (90%)] and finally talonavicular [19/30 (63.33%)]. Although, lateral talocalcaneal angle hadn’t affected yet [7/30 (23.33%)]. So, the degree of angle affection in females were ranged 14 to 25 (46.66% to 83.33%). Conclusion: wearing of high heel for long period of time had impact on different foot angels.

Key Words: Foot arches, high heel, meary’s angle, calcaneal pitch angle, talonavicular coverage angle and lateral talocalcaneal angle.

INTRODUCTION

The typical foot with twenty six bones and related muscles ensures the foot's static and dynamic capacities and adds to the general features of the foot, yet the shape and morphology varies between people. Feet morphology not just assumes a crucial role in anticipating injuries also informs sport performance, highly competitive and recreational competitors are at danger of bringing about an extensive variety of injuries and hyperkeratotic sores like corns and calluses (1). Human wear shoes were designed to secure feet, to relieve pressure, and to make human walk normal and comfortable. Hence, one rule for the choice of shoes could be the effectiveness of assurance from injuries and impacts. However, most ladies consider outline and fashion as opposed to health and comfort as their top needs when choosing shoes. It was found that 37–69% of ladies want to wear a high heel, yet high-heeled shoes with an over the top concentrate on design could instigate musculoskeletal problems, for example, plantar fasciitis, hallux valgus, lower leg sprain, and lower back pain (2).
Furthermore the peak pressures on the forefoot were 4.5–4.8 times and 2.3–2.5 times greater than those on the center foot and back foot when ladies wore high heels. Along these lines, a review on the distribution of foot pressure is important to predict the distortion related with the wearing of high heels (3). A high recurrence of wearing high-heeled shoes was related with a larger forefoot (area of the footprint) and a hallux surpassing alternate toes long. Heel rise prompts to increased pressure and shear stress on the forefoot, especially on the medial forefoot. It is especially amazing that a huge relationship was found between foot shape and shoe wearing habits in young ladies (middle age 23 years) (4).

Wearing high heels causes load shifting from the heel area toward the toe area (5). There was a review demonstrating that extreme wearing of high-heeled shoes prompts to shortening of the calf musculature so frequent high heel wearers feel awkward with level shoes (6). Past researches explored the impact of high heel on back, knee and lower leg pain; in addition, it demonstrated that high heel had an impact on foot arches (7 and 8). So this present study would be a base line to examine the impact of high heel shoes in normal female subjects.

High heels might add to changes in the muscles around the knee joint; they could likewise build the dangers of creating of patellofemoral pain (PFP) and knee osteoarthritis, by increasing the joint reaction force by means of the higher knee extensor moments and knee flexion angles incited. Heel height was related with neighborhood muscle activity, weariness, and over-loading of the muscles (9). There was an impact of high heel on foot arches, high heel did not properly support the feet which cause the tendon to weaken, so ladies who wore high heels were at hazard especially they spent extensive time of the day standing up (10). Peak pressure and shear stress shifted from lateral to the medial forefoot as the heel height increased from 30 to 70 mm. It was found that walking in high-heeled shoes (5.91 cm) increased the peak pressure on the medial forefoot in respect to low-heeled (1.95 cm) shoes (11).

Furthermore, wearing high-heeled shoes had been related with increased potential for slips and falls, by reason of the fact that the resulting changes in local sensation around the ankle may influence ladies' postural adjustment. In this manner, a few reviews had proposed that the best heel height for keeping up balance was from 3 to 5 cm. If the heel height were more noteworthy than 5 cm, ladies would tire effortlessly because it would be more troublesome for the feet to adjust the body weight (12). It was accounted for that heel thickness and height are related to walking steadiness, and might be disadvantageous for the maintenance of balance (13). A few scientists accepted that high heel shoes were the explanation behind flat feet among ladies, and the dangers were seriously expanded further on the off chance that they invest a great deal of time standing up, this cause the curve of foot to fall, which could prompt to excruciating pain and trouble walking (14). They trusted that wearing high heels and standing or walking could assume a part in this, stretching...
out, of the tendon anyway they were still uncertain (15). There was a gap between specialists who agreed and disagreed that high heel were the explanation behind flat feet among ladies. So, was there any influence of wearing high heel on different foot angels in normal female subjects?

**Design of the study:** was post design experimental study. This study was ethically approved from the ethical committee of Faculty of Physical Therapy, Cairo University, and had been conducted during the period from August to December 2016. The study was conducted in the radiological department of Kasr El-Aini Hospital.

**Subjects, Materials and Methods:**
Thirty normal female subjects’ volunteers from Faculty of Physical Therapy, Cairo University, and their age were 18-25 years old. Body mass index ranged from 18.5 to 24.9 kg/cm². Height of heel was 2 inch. They were wearing of high heel for five hour per day for eight weeks. Exclusion criteria included orthopedic problems, systemic disease or any postural abnormalities.

**Instrumentations:**

**X-ray apparatus:** Fuji computed radiography forum x-ray device model CR-IR 348CL with serial number 56227469 made in Japan. It was used to assess the different foot angels during wearing high heel through talking lateral and anteroposterior views to measure (meary’s angle, calcaneal pitch angle, talonavicular coverage angle and lateral talocalcaneal angle)

**Procedures:**
Each subject was subjected to four loaded radiographic image through standing on the lateral step of the X-ray device side by side to the vertical table, then the subject was asked to bear his body weight on the foot to be examined while the other foot and leg were maintained behind the examined foot .The lateral border of the examined foot was placed in a firm contact with the vertical table to face the X-ray buky (or cassette) while the medial border of the foot faced the X-ray beam.

1) **Anteroposterior view:**
   i. **Talonavicular coverage angle:** this measurement is taken off a weight-bearing anteroposterior .This angle represents the degree of shift of the navicular on the talus. Two lines are drawn, one connecting the edges of the articular surface of the talus, and one connecting the edges of the articular surface of the navicular. The angle formed by these two lines is the talonavicular coverage angle. An angle of greater than seven degrees indicates lateral talar subluxation, the researcher stabilize the subject for accurate measuring and when taking the x-ray the researcher stand behind the lead barrier (Figure 1) (20, 21 and 22).
2) Lateral view:

ii. **Lateral talar - 1st metatarsal angle (Meary’s angle):** This is an angle formed between the long axis of the talus and first metatarsal on a weight-bearing lateral view. This line is used as a measurement of collapse of the longitudinal arch in the normal weight-bearing foot, the midline axis of the talus is in line with the midline axis of the first metatarsal. An angle that is greater than 4° convex downward is considered pes planus with an angle of 15° - 30° considered moderate, and greater than 30° severe. An angle greater than 4 degrees convex upward is considered a pes cavus (Figure 2) (20, 21 and 22).

iii. **Calcaneal pitch:** A line is drawn from the plantar-most surface of the calcaneus to the inferior border of the distal articular surface. The angle made between this line and the transverse plane (or the line from the plantar surface of the calcaneus to the inferior surface of the 5th metatarsal head) is the calcaneal pitch the normal range of calcaneal pitch 18 to 20° is generally considered normal. The researcher stabilize the subject for accurate measuring and when taking the x-ray the researcher stand behind the lead barrier (Figure 3) (20, 21 and 22).
iv. Lateral Talocalcaneal Angle: The lateral talocalcaneal angle is the angle formed by the intersection of the line bisecting the talus with the line along the axis of the calcaneus on lateral weight-bearing views. A line is drawn at the plantar border of the calcaneus (or a line can be drawn bisecting the long axis of the calcaneus). The other line is drawn through two midpoints in the talus, one at the body and one at the neck. The angle is formed by the intersection of these axes. The normal range is 25-45 degrees (Figure 4) (20, 21 and 22).

Results:

I. Descriptive statistics of different measured angles: Mean of marry’s angle was 61.00 with minimum mean 42.00 and maximum mean 73.00 and standard deviation 7.09. Mean of calcaneal pitch angle was 27.93 with minimum mean 20.00 and maximum mean 40.00 and standard deviation 5.32. Mean of talonavicular coverage angle was 9.07 with minimum mean 5.00 and maximum mean 14.00 and standard deviation 2.46 and standard deviation 0.45. Mean of lateral talocalcaneal angle was 38.93 with minimum mean 25.00 and maximum mean 54.00 and standard deviation 7.29 (Table 1)
Table (1): Descriptive statistics of different measured angles in the studied group.

<table>
<thead>
<tr>
<th>Ankle Angle</th>
<th>No.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meary's angle</td>
<td>30</td>
<td>42.00</td>
<td>73.00</td>
<td>61.00</td>
<td>7.09</td>
<td>1.29</td>
</tr>
<tr>
<td>Calcaneal pitch</td>
<td>30</td>
<td>20.00</td>
<td>40.00</td>
<td>27.93</td>
<td>5.32</td>
<td>0.97</td>
</tr>
<tr>
<td>Talonavicular coverage</td>
<td>30</td>
<td>5.00</td>
<td>14.00</td>
<td>9.07</td>
<td>2.46</td>
<td>0.45</td>
</tr>
<tr>
<td>Lateral talocalcaneal</td>
<td>30</td>
<td>25.00</td>
<td>54.00</td>
<td>38.93</td>
<td>7.29</td>
<td>1.33</td>
</tr>
</tbody>
</table>

II. Findings of Meary’s angle: Females with Meary’s angle < 15 was considered normal, an angle of 15-30 was considered moderate and greater than 30 was considered severe. The number of females who had severe Meary's angle was twenty eight (93.33%) while there only two female had moderate Meary's angle (6.66%) (Table 2 and figure 5a).

III. Findings of calcaneal pitch angle: The number of females who had abnormal calcaneal pitch was twenty seven (90%) while only three female had abnormal calcaneal pitch (10%) (Table 2 and figure 5b).

III. Findings of talonavicular coverage angle: Females with talonavicular coverage angle ≤ 7 degree were considered normal and higher than 7 degrees were considered with lateral talar subluxation. Nineteen of the studied females (63.33%) had lateral talar subluxation and eleven females (36.66) had normal talonavicular (Table 2 and figure 5c).

IV. Findings of lateral talocalcaneal angle: It was considered normal and greater than 45 were considered abnormal. The number of females who had normal talocalcaneal angle was twenty three (76.66%) and the number of female who had abnormal talocalcaneal angle was seven (23.33%) (Table 2 and figure 5d).

Table 2: Findings of meary’s, calcaneal pitch, talonavicular coverage and lateral talocalcaneal angles

<table>
<thead>
<tr>
<th>Ankle Angle</th>
<th>Normal</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percentage</td>
</tr>
<tr>
<td>Meary's angle</td>
<td>2</td>
<td>6.66</td>
</tr>
<tr>
<td>Calcaneal pitch</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Talonavicular coverage</td>
<td>11</td>
<td>36.66</td>
</tr>
<tr>
<td>Lateral talocalcaneal</td>
<td>23</td>
<td>76.66</td>
</tr>
</tbody>
</table>
V. Percent of angles affection: As recorded from the results that there were three angles were mostly affected and had marked flat foot as follows; Meary's angle [28/30 (93.33%)], calcaneal pitch angle [27/30 (90%)], talonavicular [19/30 (63.33%)] and finally lateral talocalcaneal angle [7/30 (23.33%)]. So, the degree of angle affection in females were ranged 14 (46.66%) to 25 (83.33%) (Figure 6)

![Figure (5a): Meary's angle](image)

![Figure (5b): calcaneal pitch angle](image)

![Figure (5c): talonavicula coverage angle](image)

![Figure (5d): lateral talocalcaneal angle](image)

![Figure (6): Percent of angles affection](image)
VI. The relation between foot angels: There were three angles (Talonavicular + Meary's + calcaneal pitch) mostly clear a great effect of wearing high heel on foot arches with percentage 46.66% of total female subjects (table 6).

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talonavicular + Meary's</td>
<td>17</td>
<td>56.66</td>
</tr>
<tr>
<td>Talonavicular + calcaneal pitch</td>
<td>16</td>
<td>53.33</td>
</tr>
<tr>
<td>Talonavicular + Meary's + calcaneal pitch</td>
<td>14</td>
<td>46.66</td>
</tr>
<tr>
<td>Calcaneal pitch + Meary's</td>
<td>25</td>
<td>83.33</td>
</tr>
</tbody>
</table>

Table (6): Percentage of abnormality in combined angles

Discussion:
Females with Meary’s angle less than 15 degrees were viewed as ordinary (12), while those with 15-30 degrees were viewed as moderate as and greater than 30 were considered as severe (19). According to the recent study, the females who had extreme Meary's angle were 28 subjects (93.33%) while there was two females had moderate Meary's angle (6.67%). Females with calcaneal pitch angle from 18-20 degrees were viewed as normal while more prominent than 20 degrees were viewed as unusual (20). However in the present research, the number of females who had unusual calcaneal pitch angle were 27 ladies (90%) in addition, a single female had normal calcaneal pitch angle (10%). Females with lateral talocalcaneal angle from 25-45 degrees were considered as normal and who had more prominent than 45 degrees was viewed as abnormal (21). In the concurrent assessment, the females who had ordinary lateral talocalcaneal angle were 23 women (76.67%) with respect only to seven women who had increased talocalcaneal angle (23.33%). As recorded from the current outcomes, there were three angles were generally influenced; Meary's edge [28/30 (93.33%)], calcaneal pitch edge [27/30 (90%)] and talonavicular [19/30 (63.33%)]. In this way, the degree of angle affection in females were ranged 14 (46.66%) to 25 (83.33%).

Although numerous ladies are cautioned against the risks of wearing high heel footwear, there is restricted exact proof showing a relationship between wearing high heel with harm. Gait laboratory testing has found a higher heel height set the foot in a high susceptibility for the danger of ankle sprain. Ladies have additionally been overviewed about wearing high heel and approximately 50% of those reported inconvenience and pain after wearing a high heel shoe (23 and 24).

Females with talonavicular coverage angle equal or less than seven degrees were considered as normal while those with higher than seven degrees were considered as lateral talar subluxation (22). In the present research,
nineteen of the studied females (63.33%) had horizontal talar subluxation and eleven females (36.67%) had normal angle.

The finding of the current review revealed that the increase in talonavicular coverage angle in the considered females may result from the fact that mechanical instability might be because of particular deficiencies, for example, pathologic laxity, arthrokinematic changes, synovial irritation, or degenerative changes (25). Chronic ankle instability might be brought on by mechanical instability, functional instability, or a combination of these entities that all encouraged by wearing of high heel for a prolonged period of time (26).

The findings of the current study uncovered that exaggerated Meary’s angle may be because of the lateral deviation of the big toe, or medial deviation of the first metatarsal which was generally related with an increased first-second metatarsal angle. Researchers suggested that this distortion generally happens in the individuals who wear tight and high shoes (19-21). Constrictive footwear is subsequently thought to be a predisposing factor for falling of the longitudinal foot curve; hind foot valgus and forefoot abduction that were included in delivering the irregularities of symptomatic grown-up flatfoot (27).

Understanding the significance of the tibialis posterior tendon for the normal foot clears up its role that the tibialis posterior dysfunction leads to acquired flatfoot. The tibialis posterior tendon is the essential element stabilizer of the medial longitudinal arch and this is uncovered that wearing of high heel may bring about muscle weakness, arch instability and thus flat foot (21 and 27).

Despite the fact that the foot acts as a lever for adjustment of the body weight which should be in proper relation to it, foot when loses the passive support and control of the muscles, burden falls on the inner side and the strain upon the ligaments would occur. The disuse of function and the mechanical disadvantages to which the foot is subjected predispose to weakness and deformity (28). Another conceivable mechanical etiology is over pull of the contradicting peroneus brevis muscle. Seldom, burst of the tibialis posterior tendon has likewise been related with a traumatic occasion, for example, ankle fracture, ankle sprain, or a direct hit to the ligament. It is critical to call attention to that, in spite of the fact that the tibialis posterior tendon may rupture, this is a not necessary for tibialis posterior dysfunction to create. In like manner, iatrogenic loss of the tibialis posterior tendon does not generally prompt to a gained flatfoot deformation (29).

The results of this study comes in concurrence with different reviews reported that adult gained flat feet is an excruciating condition regular in
ladies and frequently goes undiagnosed. The review found that this condition is brought about by the steady “stretching out” of the tibialis posterior tendon which is the principle stabilizer of the foot arch and is found close to the ankle bone. A few specialists trust that wearing high heels and standing or walking could assume a part in this “stretching out” of the ligament (30).

**Conclusion:** wearing of high heel for long period of time result in decrease in different foot angels.

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تأثير إرتداء الكعب العالي على زوايا القدم المختلفة في الإناث الأصحاء

الخلفية: إن قوام القدم و الضغط الواقع على كرة القدم يغيران من خلال إرتداء الكعب العالي. ومن المعروف أن تكرار ارتداءه يرتكز الفخذيين والركبتين وكذلك يزيد من خطورة الإصابات مثل خشونة المفاصل، ومطاطة إصبع القدم، و مشاكل الظهر، و الشوكات و التقرحات الغرض: لدراسة تأثير إرتداء الكعب العالي على زوايا القدم المختلفة في الإناث الأصحاء. الأشخاص: ثلاثين إمرأة صحيحة تراوحت أعمارهم بين 18-25 سنة ؛ كانوا متطوعين. الطريقة: إن الأشخاص كن يرتدين الفعل الكعب العالي (إثان بوستة) لمدة ثمان أسابيع على الأقل . و تم إجراء أشعة إكس بالتصوير على القدم . و تم قياس أربع زوايا: زاوية ماري، وزاوية إنحراف الكعب، وزاوية الكاحل الزوريقي، وزاوية الكاحل الكاحلية العقبية الجانبية النتائج: كان هناك ثلاث زوايا المتضرة بقصوى، كان لديهم أقدام المسطحة على النحو التالي: زاوية ماري [30/28%]. وزاوية إنحراف الكعب [27/22%]، وأخيراً زاوية الكاحل الزوريقي [19/33%] . أما الزاوية الكاحلية العقبية الجانبية فلم تتأثر إطالة [32/32%] . و لذلك زادت درجة التأثر في الزوايا في الإناث من 14 إلى 25.63.64% إلى 43.33%.

الخلاصة: ارتداء الكعب العالي لفترة طويلة من الوقت يتأثر في زوايا القدم المختلفة. الكلمات الدالة: أقواس القدم، الكعب العالي، زاوية ماري، وزاوية إنحراف الكعب، زاوية الكاحل الزوريقي، وزاوية الكاحلية العقبية الجانبية.