Effect of wearing high heels on the biomechanical parameters of the foot

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Abstract

Introduction: Today's fashion and footwear market offers a wide range of stilettos. For women, stilettos are an important part of their wardrobe, providing a sense of confidence and enhancing physical attractiveness. Unfortunately, they also raise latent concerns among healthcare professionals due to the forced position of the foot. The aim of this study is to present the effect of high heels on the distribution of foot forces on the ground in adult women attending high-heels dance classes.

Material and Methods: The distribution of foot forces on the ground and the body balance of HHS female students before and after the training session were investigated. Foot arch measurements were taken using EPSR1 mats (Letsens Group, Letsens S.R.L. Via Buozzi, CastelMaggiore; Bologna, Italy).

Results: The foot arch test showed that the entire study population had highly arched left feet (mean arched level of 8.85%) and right feet (3.70%). Analysis of the data showed that training in high heels reduced the longitudinal arch of the right foot (p=0.04942) by increasing metatarsal pressure. Pressure on the heel of the right foot decreased (p=0.017621). Statistical analysis of the stabilographic measurements showed statistically significant changes only in the distance from the centre of pressure before and after the test (p=0.047531).

Conclusions: The results suggest that the development of an abnormal longitudinal arch (flatfoot) and a reduction in body balance may be attributable to prolonged wearing of high-heeled shoes.

Keywords: high-heeled shoes, feet, women, flattening of the longitudinal arch of the foot, biomechanics
Introduction

Shoes have existed for centuries. Their original purpose was to provide protection and safety for the foot when walking, with a focus on practicality. Today, with changing fashion trends, high heels are also valued for their aesthetic qualities. Both elegant and everyday footwear add height to the body and provide a sense of comfort [1].

The human foot is the foundation of the body and has a complex anatomical structure. The foot is classically divided into three parts: forefoot, midfoot, and hindfoot [2]. The foot is a strong mechanical structure made up of 28 bones, at least 30 joints, more than 100 muscles, tendons, and ligaments. These structures work together to perform two main functions: weight bearing and propulsion. To maintain the stability of the body, the foot must be flexible and adapt to the unevenness of the ground. Its surface area is small compared to other parts of the body, but it is one of the most complex structures of the human musculoskeletal system [3].

Depending on the type of movement - walking or dynamic running - the alignment of the foot and its muscle tone changes. The foot touches the ground in outward rotation (supination) and then switches to inward rotation (pronation) [4]. Acquired foot deformities can occur as a result of overloading the foot during movement. As reported in the literature, one of the most common acquired conditions is flatfoot (Latin: pes planus) [5].

Flat feet is the most common foot deformity in humans. This type of condition occurs as a result of the failure of the short muscles of the foot. Prolonged stress, with the concomitant weakening of the ligaments and muscles, leads to a lowering of the arches medially, longitudinally, laterally, and transversely, resulting in complete adhesion of the sole to the ground. The process of flatfoot formation is accompanied by heel valgus. There are different types of pain that can occur with a foot deformity. One of the earliest signs of flat feet is a deformed foot. This problem can also be identified if there is no visible clear space around the medial edge of the foot [6].

Ill-fitting uncomfortable footwear and associated excessive pressure can also cause physiological weakening of the arches. The foot in a high-heeled shoe has a limited area of support, resulting in increased pressure on the longitudinal arch, causing it to drop and increasing the common area between the sole of the foot and the insole surface of the shoe. Lack of space and unnatural foot positioning leads to foot deformity. Long-term forced positioning can affect all the musculoskeletal structures surrounding the foot, including ligaments, joint capsules, muscles, and tendons [6-7].
The emergence of many negative opinions about the impact of high heels on human health does not eliminate their use. On the contrary, the sales of stilettos are increasing day by day, as today's fashion supports their design and popularity. Women's stilettos do not only add beauty but are also an important part of women's fashion that defines personality. Women who wear high heels look more confident and mentally stronger. For this reason, appearance is also an important source of authority these days. As a result, more and more efforts are being taken to include high heels in products offered to women [8].

High heels dancing originated in American dance halls in the 19th century. It is an unusual dance technique that combines different styles such as dancehall, ballet, and jazz. Unlike other genres, high heels features dancing on thin stiletto heels. The high heels style, like other dance genres such as salsa, etc., uses high heels. Nowadays, high heels are considered one of the attributes of femininity but they also lead to pain and pathological changes in the feet. Many studies have shown that wearing high heels has negative effects on the musculoskeletal system, altering the function of the ankle joint complex and causing stress to the feet [9]. The aim of this study is to analyse the effect of high heels on the distribution of foot forces on the ground in adult women attending high heels dance classes.

**Material and Methods**

**Participants**

The study included 18 women who attended high heels dance classes where high heels are used. The mean age of the participants was 31 years (SD=7). The mean body weight of the women was 65.15 kg (SD=13.37) and the mean body height was 167.11 cm (SD=6.08). According to the standards of the World Health Organisation [10], 72.2% of the participants in the study had a normal body mass index (BMI), 22.2% of the participants struggled with overweight, and 5.6% of the women were reported to be first-degree obese. The women in the study attended dance classes once a week. All women who participated in the study met the inclusion criteria, which were: regular attendance of high-heels dance classes, a dance shoe heel height of at least 7 cm, no orthopedic injuries 6 months prior to the study, no foot conditions, no back complaints or injuries 6 months prior to the study, and no dermatosis of the feet. The research was conducted based on the consent of the Scientific Research Ethics Committee of the University of Warmia and Mazury in Olsztyn (Decision No. 9/2018).
Study design

The survey was conducted during the high-heeled dance class on 18 December 2022.

![Diagram of study design]

**Figure 1.** Recruitment process and the number of study participants

The study was initiated with a health and well-being interview to check the exclusion criteria for participation in the study. First, prior to the dance class, body height was measured using a Soehnle electronic height gauge (Soehnle, Gaildorfer Straße 6, 71522 Backnang, Germany). Body weight was measured using a Tanita InnerScan®V model BC-545N (TANITA Corporation1-14-2, Maeno-Cho, Itabashi-ku, Tokyo, Japan). Participants then stood with both feet hip-width apart on an E.P.S./R1 pedobarograph mat (Letsens Grupa Letsens S.R.L. Via Buozzi, CastelMaggiore, Bologna, Italy) while maintaining an upright posture. The device automatically
transmitted measurements to a computer using Biomech Studio software. (Letsens Grupa Letsens S.R.L. Via Buozzi, CastelMaggiore, Bologna, Italy).

While the information was being loaded through the mat (20 seconds), the participants were not allowed to move and had to remain still to avoid distorting the results. The women then actively participated in performing simple choreographed routines in high-heeled shoes, and were again subjected to an analysis of the distribution of foot forces on the ground. The recordings made it possible to determine changes in body balance and the distribution of foot forces on the ground in specific areas: forefoot, metatarsus, and heel before and after training. The study was carried out in a well-lit training room with favorable thermal conditions (22°C). The surface on which the study participants moved during training was flat, with no obvious deformations, depressions, protrusions, or architectural barriers.

Statistical analysis

Statistical analysis was performed using the STATISTICA 13.0 statistical package (Statsoft, Krakow, Poland). Descriptive statistics (Me, SD, Q1, Q3) were performed for all variables. The Shapiro-Wilk test was used to check the normality of the data. Most of the analyzed data showed inconsistency with the normal distribution, so the non-parametric Wilcoxon pairwise rank order test was used for further statistical analysis. The level of statistical significance was set at $p \leq 0.05$.

Results

The analysis of foot arches showed that the general study population was characterized by high left foot arches at an average of 8.85% and strongly high right foot arches at an average of 3.70%. Reference values to distinguish categories of the longitudinal arch were obtained from the Biomech Studio software.

The analysis showed that before the study, the left foot was characterized by a strongly high instep in 38.8% of the participants, 33.3% of the women had a high instep, while 11.1% of the participants had a slightly high instep of the left foot. Normal instep was also noted in 11.1% of the women. Only one of the participants was characterized by mild flat feet (5.5%). As a group, no changes in the longitudinal arch at the level of the flat foot and severe flatfoot were noted.
For a significant number of women, the analysis showed a strong high instep in the right foot (72.2%). A high instep of the foot was noted in 11.1% of participants and among women with a slightly high instep. Furthermore, 5.5% of the group was characterized by a normal foot instep. Other divisions of the instep (pronation) of the right foot did not occur.

Analysis of the results of the foot test under loading conditions showed a high-arched left foot (8.40%) for the entire group. It was also observed that in the test under load with high-heeled shoes, the right foot was characterized by a higher and strong high-arched foot than before the test (from 3.70% to 4.85%).

After podiatric examinations, for the left foot, the analysis showed a strong high instep in 50% and a high instep for 33.3% of participants. No values were recorded for a slightly high instep. A normal foot was found in 11.1% of women. One person had mild flat feet (5.5%). The other subdivisions of the instep (pronation) of the left foot in the participants walking in high-heeled shoes did not occur.

The analysis of the right foot showed a strong high instep of the foot (66.1%) in the majority of women. The high instep was found in 22.2% of the participants. For slightly high and normal foot instep, the values recorded were similar to the left foot, while 5.5% of participants had a flat foot. Light and severe flat feet were not observed.

The distribution of podiatric results showed that before classes in high-heeled shoes, the median was 40.40% for the forefoot, 8.85% for the midfoot, and 50.25% for the heel in the left foot. In the right foot, the median value was 29.00% for the forefoot, 3.70% for the metatarsus, and 68.25% for the heel.

In the left foot, after the tests in high-heeled shoes, the median of the analyzed statistical podological measurements increased slightly for the forefoot (from 40.40% to 41.05%) and the heel (from 50.25% to 51.80%).

In the right foot, a higher median value for the forefoot (from 29.00% to 33.65%), and the midfoot (from 3.70% to 4.85%) was noted after the test. The median for the heel of the right foot decreased by 10.35% (from 68.25% to 57.90%). Table 1 shows the distribution of test results.
Table 1. Distribution of podiatric test results before and after classes in high-heeled shoes

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th></th>
<th></th>
<th></th>
<th>After</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left Foot</td>
<td>Right Foot</td>
<td>Left Foot</td>
<td>Right Foot</td>
<td></td>
<td>Left Foot</td>
<td>Right Foot</td>
</tr>
<tr>
<td></td>
<td>Forefoot [%]</td>
<td>Metatarsus [%]</td>
<td>Heel [%]</td>
<td>Forefoot [%]</td>
<td>Metatarsus [%]</td>
<td>Heel [%]</td>
<td>Forefoot [%]</td>
</tr>
<tr>
<td>Me</td>
<td>40.40</td>
<td>8.85</td>
<td>50.25</td>
<td>29.00</td>
<td>3.70</td>
<td>68.25</td>
<td>41.05</td>
</tr>
<tr>
<td>Q1</td>
<td>37.00</td>
<td>5.10</td>
<td>43.00</td>
<td>18.00</td>
<td>3.00</td>
<td>61.90</td>
<td>34.80</td>
</tr>
<tr>
<td>Q3</td>
<td>42.80</td>
<td>17.70</td>
<td>55.60</td>
<td>31.60</td>
<td>7.10</td>
<td>76.40</td>
<td>47.10</td>
</tr>
<tr>
<td>SD</td>
<td>5.81</td>
<td>8.73</td>
<td>7.34</td>
<td>11.38</td>
<td>6.28</td>
<td>11.48</td>
<td>6.78</td>
</tr>
</tbody>
</table>

Me - median, Q - quartile, SD - standard deviation

Source: own elaboration

The value of the analyzed indices of body stability before classes in high-heeled shoes and the average for the study group are presented graphically (Table 2). The median distance of the center of pressure of the feet on the ground before classes in high-heeled shoes was 123.00 mm, while after the tests, it decreased to 120.05 mm. The results obtained for the analyzed index indicated higher motor control in the group. The median average rotational speed before the classes was 6.15 mm/s. After the classes in high-heeled shoes, this parameter decreased to 6.00 mm/s. The ratio of the distance between the extreme pivot points to the pivot area was 1.50 before and 1.35 after training. The median center of gravity (barycenter) of the body before training was 88.85 mm2. The value dropped to 84.65 mm2 after training. The second quartile of the center of gravity of the left and right foot increased (from 12.74 mm2 to 15.16 mm2 LS) and (from 9.39 mm2 to 12.52 mm2 PS).
Table 2. Distribution of stabilographic test results before and after activity in high-heeled shoes

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th></th>
<th>After</th>
<th></th>
<th>Before</th>
<th></th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Me</td>
<td>123.00</td>
<td>6.15</td>
<td>1.50</td>
<td>120.05</td>
<td>6.00</td>
<td>1.35</td>
<td>88.85</td>
</tr>
<tr>
<td>Q1</td>
<td>106.00</td>
<td>5.30</td>
<td>0.80</td>
<td>111.30</td>
<td>5.60</td>
<td>0.80</td>
<td>29.81</td>
</tr>
<tr>
<td>Q3</td>
<td>136.00</td>
<td>6.80</td>
<td>3.40</td>
<td>191.80</td>
<td>9.60</td>
<td>2.40</td>
<td>160.62</td>
</tr>
<tr>
<td>SD</td>
<td>20.65</td>
<td>1.02</td>
<td>1.93</td>
<td>52.54</td>
<td>2.63</td>
<td>1.09</td>
<td>110.16</td>
</tr>
</tbody>
</table>

C.O.P. - center of pressure, LF - left foot, RF - right foot, Me - median, Q - quartile, SD - standard deviation

Source: own elaboration

Pedobarographic evaluation showed that most women (13 of 18) had on average 3.4% lower right foot metatarsal pressure at baseline compared to that after the classes in high-heeled shoes. Two results showed no change in metatarsal pressure. Figure 2 graphically depicts the differences in the studied right foot metatarsal pressure parameter before and after dancing in high-heeled shoes. The results were obtained for a statistically significant level set at p=0.049.
Figure 2. Comparison of pressure on the metatarsal area of the right foot before and after classes in high-heeled shoes

Source: own elaboration

There were marked differences in the heel pressure of the right foot before and after the test. In most women (15 of 18), the heel pressure of the right foot was on average 9% higher before the study. A statistically significant result (at $p=0.0176$) was obtained. Figure 3 shows graphical differences in the studied parameter of right foot heel pressure before and after dancing in high-heeled shoes.
Figure 3. Comparison of pressure on the heel area of the right foot before and after classes in high-heeled shoes

Source: own study

Statistical analysis of the stabilographic measurements showed statistically significant changes only in the distance of the center of pressure before and after the test. C.O.P distance increased in 12 of 18 women by an average of 23%. The result was statistically significant at p=0.0478. Figure 4 shows a graphical analysis of stabilographic measurements of the distance of the center of pressure before and after classes in high-heeled shoes.
Figure 4: Comparison of the distance of the body’s center of gravity before and after classes in high-heeled shoes
Source: own study

The other podiatric parameters studied regarding the distribution of forces on the ground and the stabiliographic examination performed before and after dancing in high heels (illustrated in Table 3) showed no statistically significant differences.
Table 3. Tested parameters before and after dancing in high-heeled shoes

<table>
<thead>
<tr>
<th>Pair of variables</th>
<th>The Wilcoxon paired order test</th>
<th>N</th>
<th>T</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>B Front [%] &amp; A Front [%]</td>
<td>The marked results are significant with p &lt; 0.050</td>
<td>18</td>
<td>75,000</td>
<td>0.647</td>
</tr>
<tr>
<td>B Back [%] &amp; A Back [%]</td>
<td></td>
<td>18</td>
<td>75,000</td>
<td>0.647</td>
</tr>
<tr>
<td>B Left side [%] &amp; A Left side [%]</td>
<td></td>
<td>18</td>
<td>64,000</td>
<td>0.349</td>
</tr>
<tr>
<td>B Right side [%] &amp; A Right side [%]</td>
<td></td>
<td>18</td>
<td>64,000</td>
<td>0.349</td>
</tr>
<tr>
<td>B LF Forefoot [%] &amp; A LF Forefoot [%]</td>
<td></td>
<td>18</td>
<td>65,500</td>
<td>0.384</td>
</tr>
<tr>
<td>B LF Metatarsal [%] &amp; A LF Metatarsal [%]</td>
<td></td>
<td>18</td>
<td>69,000</td>
<td>0.472</td>
</tr>
<tr>
<td>B LF Heel [%] &amp; A LF Heel [%]</td>
<td></td>
<td>18</td>
<td>48,000</td>
<td>0.301</td>
</tr>
<tr>
<td>B RF Forefoot [%] &amp; A RF Forefoot [%]</td>
<td></td>
<td>18</td>
<td>53,000</td>
<td>0.157</td>
</tr>
<tr>
<td>B Distance/area [LFF] &amp; A Distance/area [LFF]</td>
<td></td>
<td>18</td>
<td>55,500</td>
<td>0.191</td>
</tr>
<tr>
<td>B Body C.O.P. [mm2] &amp; A Body C.O.P. [mm2]</td>
<td></td>
<td>18</td>
<td>46,000</td>
<td>0.085</td>
</tr>
<tr>
<td>B C.O.P. LF [mm2] &amp; A C.O.P. LF [mm2]</td>
<td></td>
<td>18</td>
<td>52,000</td>
<td>0.145</td>
</tr>
<tr>
<td>B C.O.P. RF [mm2] &amp; A C.O.P. RF [mm2]</td>
<td></td>
<td>18</td>
<td>46,000</td>
<td>0.085</td>
</tr>
</tbody>
</table>


The significance level in the study was set at p < 0.05.

Source: own study

Discussion

This study analyzed the effect of high-heeled footwear on the distribution of ground forces in women participating in high heels dance classes. The results can provide information on the consequences of wearing stilettos on the lower surface of the feet to effectively increase public awareness and take preventive measures [11].

Comparable results were obtained in a study by Jaroslaw Jaszczur-Nowicki, who determined changes in the longitudinal arch of the foot in women who participated in beauty contests and regularly wore high-heeled shoes. Pedobarographic evaluation showed that most of the women studied had a hallux valgus toe. In 14 of the 19 participants, forefoot loading was determined to be 0-7%. (Normal forefoot loading ranges from 21.1% - 28.0%). Slight to moderate elevation of the arches of the right and left foot was noted in four participants. Only one person was characterized by normal foot arches. During the study, the load induced by high heels (10 cm) was measured at rest and after 60 minutes of walking. This study showed that along with the
unnatural position caused by heel height, the use of stilettos affects forefoot strain and can lead to negative consequences for the lower extremities, foot overload, and deformity [12].

Similar to the present study, the effects of occasional and regular wearing high-heeled shoes on static balance in young women were studied by Japanese researchers at Kanagawa University. The participants were divided into two groups - women who walked regularly in high-heeled shoes and those wearing stilettos occasionally. Each participant was first asked to stand quietly on an energy platform without shoes, and then in high-heeled shoes measuring 7 cm. The results showed that the women who occasionally walked in high-heeled shoes exerted more effort in maintaining balance and body stability. Changes in static balance control were also observed in women who routinely wore high-heeled shoes, but the index showed smaller values [13].

A similar study was conducted by the authors of a paper entitled "Assessment System for Predicting Maximal Safe Range for Heel Height by Using Force-Sensing Resistor Sensors and Regression Models", who examined the body's ability to predict and adapt to changes resulting from wearing high-heeled shoes and the effect of sole pressure. The results of the study provided evidence that in footwear with heel heights of 8 and 10 cm, gait biomechanics were altered, balance tolerance was reduced, and sole pressure on both feet was increased. There were clear differences in the sole pressure of the right foot on the forefoot, with the result showing statistically significant changes [14].

Other researchers have also studied the effects of wearing high-heeled shoes on body balance and range of motion. Hapsari and his colleagues conducted a study on thirty young women who wore shoes with four different heel heights: 1 cm (flat), 4 cm (low), 7 cm (medium), and 10 cm (high). The results indicated changes in heel elevation, which resulted in greater strain on lower limb muscles. Significant changes in body balance were observed when the heel height was 7 and 10 cm [15].

The consequences of women wearing high-heeled shoes were investigated in an experiment conducted by Zeng and a team of researchers. The aim of the study was to compare kinematic and kinetic parameters, and muscle function during walking and maintaining balance between wearing high-heeled shoes and flat footwear. Women who wore high-heeled shoes (HHS) showed greater ground reaction forces, accompanied by a forward shift of sole thrust compared to women wearing flat shoes or walking barefoot. In addition, significant effects indicated that
wearing HHS led to an impairment of both static and dynamic balance [16], confirming the results obtained in the present study.

An analysis of the issue of the effect of wearing high-heeled shoes on the distribution of forces on the ground and body balance was undertaken by Polish researchers Mucha et al. The purpose of their study was to assess the degree of foot arches and their pressure on the ground among female students of the Podhale State University of Applied Sciences in Nowy Targ. A 2D podoscope was chosen to assess the above criteria. Height and weight measurements were used to calculate BMI and the results were related to the state of foot arches and the pressure forces on their sole surface. Based on the determination of the Clarke angle, the longitudinal arch state of the foot was assessed. The results showed that, as a stress factor on the feet, being overweight or obese can lead to a decrease in the longitudinal arches of the foot, but the women studied were within normal limits. [17].

The authors of the publication conducted a similar study among a specific group of students, where they presented the results of analyses of the distribution of foot pressure on the ground and analyzed the body balance before and after exercise, the status of which was determined as a stress factor for the feet. The results showed statistically significant differences in the physiological parameters of the feet and the functional performance of the body balance system under different measurement conditions as a response to exercise stimuli. Comparative evaluation of tests during rest and after physical activity of a group of students showed negative changes in the arches of the feet, leading to flattening of the transverse arch of the foot (flatfoot) [18].

The same authors also looked at the distribution of ground pressure in children before and after kinesthetic stimulation. They conducted a study in two groups of children aged 7-12 years. The experimental group consisted of children attending dance classes, while the control group consisted of their peers in compulsory physical education classes. The authors found statistically significant differences between the mean scores of the participants at p<0.05 occurring before and after the introduction of kinesthetic stimulation. These results allowed the authors to conclude that dance significantly affects the postural stability of the body and the distribution of forces on the ground [19].

Flat feet can be caused by a variety of factors, including some sports. For their study, Husain et al. conducted an analysis of the distribution of foot pressure on the ground in football and soccer players. Individuals participating in the sport of football are at risk of injury, discomfort,
and reduced performance due to shoe design and repetitive sole loading. The results of the study showed that pain and the highest pressure were recorded most often in the forefoot, resulting in future fractures of the metatarsal bones [20].

A study on the distribution of sole pressure in football players was also undertaken by Hawrylak et al. The aim of their study was to compare the static and dynamic distribution of foot pressure on the ground and to investigate the relationship between body mass index (BMI) and mean sole pressure values in football players and non-athletes of the same age. The results showed that during the dynamic test, football players had higher forefoot loading and lower rearfoot loading in both the right and left lower limbs. However, no significant statistical differences were observed between the study groups in terms of the parameters analysed [21].

Strength and endurance training is not a sport in itself but a component of training in many sports that can contribute to or increase the risk of developing flatfoot. Exercise with loading elements can cause significant overload on the musculoskeletal system and alter the shape of foot arches. This was demonstrated in a study by Bibro et al. In the group subjected to resistance exercise, statistically significant modifications were noted in the load distribution of various foot zones including the forefoot, particularly in the medial area. It was important to note that specific changes were not observed in the control group [22].

Long-distance endurance running, especially on hard surfaces, can lead to an increased number of injuries especially to the lower extremities, such as the knee, shin, foot, and upper leg. The analysis and disclosure of soleus load among runners was undertaken by Mei et al. The results of the study showed significant changes in the height of the foot arch, the medial part of the foot, and the metatarsal after running a distance of 20 km. The concentration of load in the aforementioned zones can lead to discomfort and contribute to the weakening of the muscles and ligaments of the foot, resulting in a lowering of the longitudinal foot arch [23].

A study of soleus pressure distribution in novice runners was conducted by Brazilian researchers Silva et al. The study included 114 runners from sports clubs in the state of São Paulo. A pressure platform was used to assess the distribution of soleus pressure. The participants were divided into three groups based on their foot types. The majority of runners in the group were characterized by a high foot arch, some had a foot with a normal arch and the smallest number of people had flatfoot. The results of the study showed an increase in sole loading in the forefoot and
lateral metatarsal area in novice runners with a high foot arch, while those with flat feet had increased loading in the metatarsal area [24].

Conclusions

The present study analysed the effect of wearing high heels on the distribution of foot forces on the ground in adult women attending high heels dance classes. The analysis carried out in the study confirmed the initial assumptions, and the results are comparable to those obtained in previous investigations carried out by different authors on foot morphology disorders and their distribution on the ground.

The experiment showed that long-term wearing of high-heeled shoes induces changes in the alignment of the bones, joints, and muscles of the feet, thus leading to the formation of an abnormally arched longitudinal arch of the foot (flat feet). A significant difference in the ability to maintain postural balance was found in relation to the centre of gravity of the right foot, where greater instability was noted after loading.

From the analysis of the study, it can be concluded that high heels cause elevation of the heel bone. As a result, the body's equilibrium level decreases, as demonstrated by the findings of the study.

People who wear high-heeled shoes may be more prone to lower limb injuries than those who wear flat shoes. However, this does not mean that high-heeled shoes only have a negative impact. In women whose longitudinal arches of the foot are characterized by high hollowing, wearing stilettos can have a positive effect. The analysis of the above studies reveals that the stress of high heels leads to the formation of pes planus. It is likely that the occasional wearing of stilettos in women with a pronounced hollowing of the longitudinal arch may result in normal articulation.

Some aspects require further research. In order to analyse the problem in more detail, a study needs to take into account which lower limb is the supporting leg in the women studied. Another aspect that would need to be analysed when researching the impact of high-heeled footwear is the design elements of the footwear such as heel height and width. It is also important to consider individual factors such as the level of physical activity, genetics, or possible injuries.
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**Informed consent statement:** Informed consent was obtained from all participants involved in the study.

**Data availability statement:** The data presented in this study are available on request from the corresponding author.

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