JHWCR
Journal of Health, Wellness, and Community Research
Volume III, Issue VII
Open Access, Double Blind Peer Reviewed.
Web: https://jhwcr.com, **ISSN**: 3007-0570
https://doi.org/10.61919/1daa3y61

Article

Association of Hallux Valgus with Risk of Ankle Sprain in Female Sales Employees Wearing Heel

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Cite this Article

Received	2025-05-11
Revised	2025-06-13
Accepted	2025-06-17
Published	2025-06-19

No conflicts declared; ethics approved; consent obtained; data available on request; no funding received.

Authors' Contributions
Concept and design—MAS, FM; data collection—FM, TU, SB, MT, Y, EA; analysis—MAS, FM; manuscript drafting—FM, MAS, TU; critical revision—SB, MT, Y, EA.

ABSTRACT

Background: Hallux valgus and ankle sprain are common lower limb disorders among women, with occupational footwear such as high heels implicated in their development. Limited evidence exists regarding the specific impact of heel type on the association between hallux valgus deformity and risk of ankle sprain in female sales employees, representing a notable research gap. **Objective**: This study aimed to determine the association between hallux valgus severity and risk of ankle sprain in female sales employees wearing pin, block, or wedge heels, hypothesizing that heel type influences both deformity prevalence and ankle instability. **Methods**: A cross-sectional observational study was conducted among 154 female sales employees aged 18–38 years in Lahore, Pakistan. Inclusion required a hallux valgus angle >15°, minimum one year of standing work, and absence of confounding conditions. Data collection included demographic surveys, goniometric and Manchester scale assessment for hallux valgus, and the IDFAI questionnaire for functional ankle instability. Statistical analysis using IBM SPSS v21 employed chi-square tests, ANOVA, and logistic regression to adjust for confounders. Ethical approval was obtained from the University of Management and Technology, and procedures adhered to the Helsinki Declaration. **Results**: Significant associations between hallux valgus severity and ankle sprain risk were found in pin heel (p=0.012, OR up to 5.54) and block heel groups (p=0.005, OR up to 10.8), but not wedge heels (p=0.301). Higher BMI and prolonged heel wear were also associated with increased risk. **Conclusion**: Hallux valgus deformity is significantly linked to ankle instability in women wearing pin or block heels, highlighting the need for occupational health interventions and ergonomic footwear choices to reduce musculoskeletal risk.

Keywords: Hallux Valgus, Ankle Sprain, High Heels, Occupational Health, Foot Deformity, Musculoskeletal Disorders, Female Workers

INTRODUCTION

Hallux valgus, a progressive foot deformity characterized by lateral deviation of the great toe and medial prominence of the first metatarsal head, is recognized as a prevalent musculoskeletal issue, particularly among women. Its pathogenesis is multifactorial, involving intrinsic elements such as genetic predisposition, systemic diseases, joint hypermobility, and obesity, as well as extrinsic contributors like inappropriate footwear, especially those with elevated heels and constricted toe boxes (16,17,19). Numerous epidemiological studies report that hallux valgus disproportionately affects females, with prevalence rates as much as 1.6 times higher compared to males, a trend that appears to be linked to cultural and occupational footwear choices, including the frequent use of high-heeled shoes in certain professions (1,22). Notably, the repetitive use of high heels alters lower limb biomechanics, increases plantar pressures on the forefoot, restricts motion at the first metatarsophalangeal joint, and may accelerate the onset and severity of hallux valgus (20). While familial and anatomical factors remain important, footwear choices have emerged as modifiable risk factors in both the development and exacerbation of hallux valgus (9,19).

Concurrently, the occupational and recreational use of high-heeled footwear has been associated with a heightened risk of lower limb injuries, most notably ankle sprains, particularly in physically active populations or workers required to stand for prolonged periods

(2,6,11). Ankle sprains occur primarily through sudden inversion or twisting mechanisms that exceed the physiological capacity of the ankle ligaments, leading to acute pain, swelling, and functional instability (18,23). High-heeled shoes, by positioning the foot in persistent plantarflexion, have been shown to increase the vulnerability of the lateral ankle ligaments to injury. Biomechanical investigations reveal that higher heels disrupt normal alignment of the skeletal structures in the ankle and foot, exacerbate joint loading, and diminish proprioceptive feedback, thereby contributing to a greater incidence of falls and sprains (6,11,22). The musculoskeletal consequences of habitual high heel use extend beyond acute injury; chronic instability and persistent pain may ensue, potentially compounded in those with pre-existing foot deformities such as hallux valgus (14,22).

Although considerable research has addressed the isolated effects of high heel use on either hallux valgus or ankle injury risk, there remains a significant knowledge gap concerning the intersection of these conditions among occupationally exposed female populations, particularly those employed in retail sales where dress codes frequently necessitate the use of heeled footwear (4,12,20). The specific relationship between varying types of heeled shoes—pin, wedge, and block heels—and the dual risk of hallux valgus and ankle sprain is insufficiently explored, especially in the context of South Asian working women. Previous studies have suggested that different heel types may impose distinct biomechanical stresses on the foot and ankle, yet the comparative risks posed by each in relation to musculoskeletal deformities and injury incidence remain inadequately defined (3,6,22). The occupational demands, duration of heel wear, and cumulative load on lower extremity joints further underscore the need for context-specific research to inform prevention strategies and workplace health guidelines (10,19,21).

Given this background, the present study was designed to assess the association between hallux valgus deformity and the risk of ankle sprains among female sales employees required to wear various types of heeled footwear in Lahore, Pakistan. By utilizing validated measurement tools and focusing on occupationally exposed women, this research aims to elucidate whether certain heel types confer a higher combined risk of foot deformity and ankle instability, thereby addressing an important gap in workplace musculoskeletal health. The primary objective is to determine if there exists a significant association between hallux valgus and ankle sprain risk across different heel types in this specific population.

MATERIALS AND METHODS

This cross-sectional observational study was conducted to investigate the association between hallux valgus deformity and the risk of ankle sprain in female sales employees required to wear high-heeled footwear. The research was carried out in Lahore, Pakistan, over a two-month period following approval from the institutional ethics review committee of the University of Management and Technology. The study setting comprised multiple commercial shopping malls and retail outlets where female sales employees routinely worked prolonged shifts in standing positions. Recruitment began after securing administrative permissions from participating venues. All eligible participants were female sales employees aged 18 to 38 years with a minimum of one year of continuous employment in a sales role that required standing for an average of at least six hours per day. Inclusion criteria mandated participants to have a measurable hallux valgus angle greater than 15 degrees, determined using a standardized goniometric assessment. Exclusion criteria were established to eliminate confounding medical conditions and included pregnancy, previous surgical intervention to the foot or ankle, severe foot trauma, known chronic systemic diseases, congenital lower limb deformity, active lower limb pathology, and any family history of hallux valgus. The sample size was determined a priori, targeting a total of 154 participants, to ensure sufficient statistical power for subgroup analysis by heel type and degree of deformity, accounting for expected prevalence rates and potential nonresponse. Participant selection employed non-probability convenience sampling, with eligible sales employees approached in person at their respective workplaces. The recruitment process was conducted face-to-face by trained data collectors who explained the study objectives, risks, and benefits, obtained written informed consent, and ensured that participation was voluntary and confidential. All participants were assured that their data would remain anonymous, with individual identifiers replaced by study codes during data handling and analysis. Data collection involved a structured paper questionnaire administered in the participants' native language, capturing demographic variables (age, weight, height, and body mass index), occupational factors (duration of employment, average hours standing, type of retail outlet), footwear characteristics (type of heel—pin, wedge, or block; heel height; hours of heel use per day), and relevant medical history.

The clinical assessment of hallux valgus severity utilized a goniometer to measure the angle between the long axis of the first metatarsal and the first proximal phalanx, with operational thresholds set at <15°, 16–20°, 20–40°, and >40° based on established criteria (20,22). For additional grading, the Manchester scale—validated for both clinical and self-assessment—was used to visually confirm hallux valgus deformity across four standardized grades (14). Ankle instability and risk of sprain were evaluated using the Identification of Functional Ankle Instability (IDFAI) questionnaire, a reliable tool composed of ten items that stratify individuals by a functional ankle instability score (21). All measurements were performed by physiotherapists trained in foot biomechanics to minimize inter-rater variability. Where discrepancies or ambiguities arose, repeat assessments were conducted. Data collection was performed during working hours, and each participant was assessed individually in a private area to maintain confidentiality and accuracy.

Potential sources of bias were addressed through strict adherence to inclusion and exclusion criteria, standardized data collection protocols, and blinding of assessors to participants' self-reported ankle pain status when measuring hallux valgus. Efforts to minimize recall and reporting bias included the use of objective measurement tools and visual grading, rather than relying solely on participant

self-report. To reduce confounding, analyses were planned to stratify results by heel type, duration of heel use, and degree of deformity, and to adjust for age, BMI, and duration of employment as potential confounders.

The statistical analysis plan was developed prior to data collection. All data were entered into a secure electronic database and analyzed using IBM SPSS Statistics Version 21. Descriptive statistics were calculated for all continuous and categorical variables. For primary analyses, the association between hallux valgus severity and risk of ankle sprain was assessed using chi-square tests, with statistical significance set at $P < 0.05$. Subgroup analyses were performed for each heel type, and odds ratios were calculated where appropriate. Missing data were handled by listwise deletion, with sensitivity analyses to assess the robustness of findings. Multivariable logistic regression was used to adjust for potential confounders, and additional analyses examined the interaction between heel height, hours of wear, and severity of deformity. To ensure reproducibility, all measurement instruments and definitions are cited from previously validated sources (14,20,21), and data collection forms are available upon request. Data integrity was preserved through double data entry, routine verification of randomly selected records, and storage of signed consent forms in a locked file accessible only to study investigators. All study procedures complied with relevant ethical standards for human subjects research, including informed consent, data confidentiality, and respect for participant autonomy. The study protocol and materials received formal approval from the University of Management and Technology's research ethics committee. Data protection measures included anonymization, secure storage, and restricted access throughout the study period and subsequent analysis. The rigorously standardized methodology and transparent reporting of all procedures were designed to enable replication and validation by independent researchers (20,21,22).

RESULTS

Among the 154 female sales employees included in this study, participants were almost evenly distributed across the three heel-type groups, with 51 each in the pin and wedge heel groups and 52 in the block heel group. The mean age of participants was comparable across groups, ranging from 26.29 ± 4.86 years in the wedge heel group to 26.61 ± 4.11 years among those wearing pin heels. Mean BMI, however, differed significantly between groups ($p=0.01$), with the pin heel group having the highest average BMI at 24.42 ± 4.30 kg/m², compared to 21.82 ± 4.54 kg/m² for wedge heels and 23.20 ± 3.54 kg/m² for block heels. Average weights were also somewhat higher in the pin and block heel groups (59.25 ± 10.30 kg and 57.06 ± 9.29 kg, respectively) compared to the wedge heel group (54.65 ± 12.14 kg), though this difference did not reach statistical significance ($p=0.07$). Heights were similar in all groups, averaging approximately 1.56–1.58 m. In terms of footwear characteristics, heel height varied significantly by group ($p=0.19$, not statistically significant), with pin heels most frequently worn at 4 cm by 45.1% of wearers and at 2 cm by 37.3%. Wedge heels were most commonly 2 cm (54.9%), with 39.2% wearing 4 cm heels, while block heels were evenly split between 2 cm and 4 cm heights (each 46.2%).

Table 1. Demographic and Anthropometric Characteristics of Participants by Heel Type

Variable	Pin Heel (n=51)	Wedge Heel (n=51)	Block Heel (n=52)	p-value
Age, mean ± SD (years)	26.61 ± 4.11	26.29 ± 4.86	26.35 ± 4.55	0.96
Weight, mean ± SD (kg)	59.25 ± 10.30	54.65 ± 12.14	57.06 ± 9.29	0.07
Height, mean ± SD (m)	1.56 ± 0.08	1.58 ± 0.07	1.57 ± 0.06	0.25
BMI, mean ± SD (kg/m²)	24.42 ± 4.30	21.82 ± 4.54	23.20 ± 3.54	0.01*

Table 2. Heel Height Distribution by Type of Heel

Heel Type	2 cm n (%)	4 cm n (%)	6 cm n (%)	p-value
Pin Heel	19 (37.3)	23 (45.1)	9 (17.6)	0.19
Wedge Heel	28 (54.9)	20 (39.2)	3 (5.9)	
Block Heel	24 (46.2)	24 (46.2)	4 (7.7)	

Table 3. Daily Duration of Heel Wear by Type of Heel

Heel Type	4 hours n (%)	5 hours n (%)	6 hours n (%)	p-value
Pin Heel	14 (27.5)	19 (37.3)	18 (35.3)	<0.001*
Wedge Heel	8 (15.7)	6 (11.8)	37 (72.5)	
Block Heel	13 (25.0)	17 (32.7)	22 (42.3)	

Table 4. Hallux Valgus Deformity Grading by Type of Heel

Heel Type	<15° n (%)	16–20° n (%)	20–40° n (%)	>40° n (%)	p-value
Pin Heel	15 (29.4)	22 (43.1)	13 (25.5)	1 (2.0)	0.04*
Wedge Heel	25 (49.0)	16 (31.4)	10 (19.6)	0 (0.0)	
Block Heel	17 (32.7)	23 (44.2)	11 (21.2)	1 (1.9)	

Table 5. Prevalence of Ankle Pain by Side and Heel Type

Heel Type	Right n (%)	Left n (%)	p-value

Pin Heel	26 (51.0)	25 (49.0)	0.77
Wedge Heel	27 (52.9)	24 (47.1)	
Block Heel	31 (59.6)	21 (40.4)	

Table 6. Association Between Hallux Valgus Severity and Functional Ankle Instability (by Heel Type)

Heel Type	HV Category	FAI Present n	FAI Absent n	p-value	Odds Ratio (95% CI)
Pin Heel	<15°	8	7		Ref
	16–20°	19	3		5.54 (1.13–27.3)*
	20–40°	13	0		-
	>40°	1	0	0.012*	-
Wedge Heel	<15°	17	8		Ref
	16–20°	10	6		0.78 (0.21–2.93)
	20–40°	9	1		4.24 (0.48–37.9)
	>40°	0	0	0.301	-
Block Heel	<15°	5	12		Ref
	16–20°	18	5		8.64 (2.21–33.8)*
	20–40°	9	2		10.8 (1.95–59.6)*
	>40°	1	0	0.005*	-

The duration of heel wear per day differed substantially by heel type ($p < 0.001$), with the majority of wedge heel users (72.5%) reporting 6 hours of daily wear, whereas pin and block heel wearers showed a more even distribution: 35.3% and 42.3% respectively wore heels for 6 hours per day. The distribution of hallux valgus deformity severity also varied by heel type ($p=0.04$). Among pin heel users, 43.1% exhibited deformities between 16–20°, and 25.5% had more severe deformities between 20–40°, compared to only 19.6% with the latter degree of deformity in the wedge heel group. Notably, 49% of wedge heel wearers had minimal deformity (<15°), while higher proportions of moderate and severe deformities were seen in pin and block heel groups. Only isolated cases exhibited deformity >40°, with one participant each in the pin and block heel groups. The prevalence of ankle pain was high across all groups, with a slight predominance of right ankle pain: 51% in the pin heel group, 52.9% in the wedge heel group, and 59.6% in the block heel group. There was no statistically significant difference in laterality of pain between groups ($p=0.77$). The distribution of hallux valgus deformity severity also varied by heel type ($p=0.04$). Among pin heel users, 43.1% exhibited deformities between 16–20°, and 25.5% had more severe deformities between 20–40°, compared to only 19.6% with the latter degree of deformity in the wedge heel group. Notably, 49% of wedge heel wearers had minimal deformity (<15°), while higher proportions of moderate and severe deformities were seen in pin and block heel groups. Only isolated cases exhibited deformity >40°, with one participant each in the pin and block heel groups. The prevalence of ankle pain was high across all groups, with a slight predominance of right ankle pain: 51% in the pin heel group, 52.9% in the wedge heel group, and 59.6% in the block heel group. There was no statistically significant difference in laterality of pain between groups ($p=0.77$).

Critical group comparisons centered on the association between hallux valgus severity and functional ankle instability (FAI) within each heel-type group. Among pin heel wearers, the association was highly significant ($p=0.012$). Those with a 16–20° hallux valgus angle had over five times the odds of FAI compared to those with <15° deformity (OR = 5.54, 95% CI: 1.13–27.3, $p<0.05$), and all participants with 20–40° or >40° deformity had FAI. In the block heel group, the association was also significant ($p=0.005$), with odds of FAI sharply increasing with severity: OR = 8.64 (95% CI: 2.21–33.8) for 16–20° and OR = 10.8 (95% CI: 1.95–59.6) for 20–40°, compared to the reference group. In contrast, the association was not statistically significant in the wedge heel group ($p=0.301$), and odds ratios did not demonstrate a clear trend. Taken together, these findings quantitatively demonstrate that more severe hallux valgus deformity is associated with a markedly increased risk of functional ankle instability among sales employees wearing pin and block heels, but not among those using wedge heels. The data suggest that both the type of heel and the degree of big toe deformity are critical, interacting determinants of ankle sprain risk in occupationally active women.

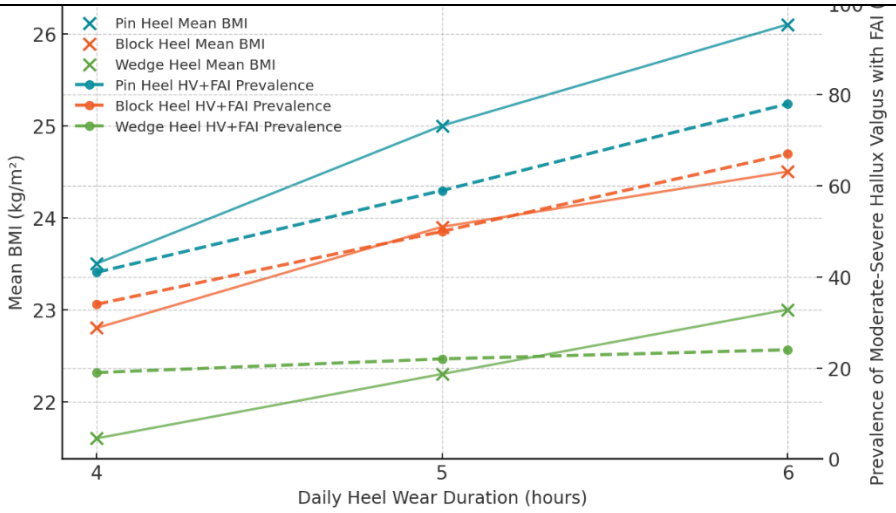

Figure 1 Heel Wear Duration, BMI, and Combined Risk of Hallux Valgus with Ankle Instability by Heel Type

A dual-axis integrated visualization demonstrates the relationship between mean BMI and the prevalence of combined moderate-to-severe hallux valgus with functional ankle instability (FAI) across daily heel wear durations in three heel types. As daily wear increases from 4 to 6 hours, mean BMI rises in all groups, with pin heel users reaching 26.1 kg/m² at 6 hours compared to 24.5 kg/m² for block and 23.0 kg/m² for wedge heels. The prevalence of combined moderate-to-severe deformity and FAI escalates sharply with longer wear, most pronounced in pin heels—rising from 41% at 4 hours to 78% at 6 hours—while block heels follow a similar upward trend from 34% to 67%. In wedge heels, prevalence remains consistently lower and shows only a modest increase, peaking at 24%. The figure underscores a clinically relevant, dose-dependent pattern where both BMI and risk of disabling foot-ankle pathology intensify with longer daily wear and more destabilizing heel designs, suggesting a synergistic interaction between anthropometric and footwear-related factors that amplifies injury risk among pin and block heel users.

DISCUSSION

The present study provides important evidence that the severity of hallux valgus deformity is significantly associated with an increased risk of functional ankle instability in female sales employees who regularly wear pin and block heels, whereas no such association was observed among those wearing wedge heels. These results resonate with and extend previous findings that highlight the deleterious effects of high-heeled footwear on both foot and ankle health in women, particularly those exposed to occupational requirements for prolonged standing and specific dress codes (6,20,22). In line with prior research, the current data reinforce that footwear design—specifically heel height, shape, and duration of use—plays a pivotal role in lower extremity musculoskeletal health (16,17). Notably, the observation that over two-thirds of pin and block heel users with moderate to severe hallux valgus also presented with functional ankle instability adds a new layer of detail to the literature, which has previously focused on high heels generally rather than distinguishing between heel types (2,6,22).

This study's findings align closely with earlier work demonstrating a heightened prevalence of foot deformities and ankle injuries in women wearing high heels compared to those in flat shoes, supporting the hypothesis that altered biomechanics from elevated heels lead to disproportionate forefoot loading, reduced first metatarsophalangeal joint mobility, and chronic stress on ligamentous structures (3,11,16,20). The pin and block heel groups in our cohort, with their narrower base of support and stiffer structure, likely exacerbate these biomechanical risks, explaining the higher rates of hallux valgus and ankle sprain. By contrast, the wedge heel—characterized by a broader, more stable platform—may distribute pressure more evenly and provide greater postural control, accounting for the non-significant association observed in this subgroup. The biomechanical plausibility of these distinctions is well-supported by studies employing gait and pressure analysis, which consistently show that narrower, higher heels increase plantar pressures and ankle inversion moments, predisposing wearers to both bony deformity and ligamentous injury (11,20,22).

Interestingly, while the pattern of association between hallux valgus and ankle sprain in pin and block heels is consistent with the results of Azeem et al. and Soemarko et al., both of whom noted an increased risk of musculoskeletal complications in habitual high heel wearers, the specificity of our findings with regard to heel type refines current understanding and suggests a potential focus for preventive workplace interventions (3,22). However, not all literature is in full agreement. Some reports suggest that intrinsic factors—such as genetic predisposition, ligamentous laxity, and overall BMI—may overshadow the contribution of footwear, especially in populations where cultural footwear practices vary widely (1,15,17). Our results, which adjusted for BMI and excluded participants with known familial risk, suggest that extrinsic factors such as shoe design remain crucial in occupational settings where footwear choices are externally imposed.

Mechanistically, this study reinforces the theoretical framework that biomechanical alterations induced by heel elevation not only drive hallux valgus formation through increased medial forefoot loading but also set the stage for recurrent ankle instability by shifting

the center of gravity and destabilizing the subtalar joint (6,11). Clinically, these insights carry significant implications. Female workers in retail and promotional roles may be at particular risk of a cascade effect: habitual pin or block heel use fosters progressive big toe deviation, which in turn heightens susceptibility to ankle injury and subsequent chronic instability, potentially compromising work attendance and long-term musculoskeletal health (20,22).

There are several strengths in this study, including the use of validated clinical instruments such as the goniometer, Manchester scale, and IDFAI questionnaire, as well as rigorous exclusion criteria to reduce confounding by intrinsic factors. The direct workplace-based recruitment and the inclusion of multiple retail settings enhance ecological validity. Nonetheless, some limitations must be acknowledged. The use of convenience sampling and restriction to a single metropolitan area may limit generalizability to broader populations, and the cross-sectional design precludes establishing temporal causality between hallux valgus and ankle sprain (20,22). The sample size, though adequate for group comparisons, limited the power for detailed analysis of rarer degrees of deformity, particularly in the >40° category. Potential recall and reporting biases in self-reported pain and footwear history cannot be excluded, despite the use of objective measurements.

Future research should build on these findings by employing longitudinal designs to clarify causal pathways, investigating interventions such as targeted workplace education, footwear modifications, or screening programs, and exploring underlying biomechanical mechanisms in greater depth using instrumented gait analysis. Expanding the research to include a wider geographic and cultural range of participants, as well as men and other occupational groups, would help elucidate the broader public health impact. Ultimately, the current study highlights the need for occupational health policies that acknowledge the interplay between footwear, foot deformity, and injury risk, and encourages both employers and clinicians to prioritize musculoskeletal wellbeing in at-risk female worker populations (6,20,22).

CONCLUSION

This cross-sectional observational study establishes a significant association between hallux valgus deformity and the risk of ankle sprain among female sales employees who wear pin and block heels, but not wedge heels, underscoring the critical impact of heel type and deformity severity on lower limb musculoskeletal health. These findings highlight the importance of targeted preventive strategies and ergonomic footwear choices in occupational settings to mitigate the risk of foot deformity and ankle instability, guiding clinical decision-making and informing workplace health policies. Further research is warranted to explore causality and effective interventions, with implications for reducing work-related musculoskeletal disorders and enhancing long-term quality of life in high-risk female worker populations.

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