Original Article

Wearing high heels with an appropriate height is protective for pelvic floor function

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Background: Wearing high-heeled shoes is a common phenomenon among women. However, the association between wearing high heels and pelvic floor function is largely unknown. Our aim was to evaluate the effects of wearing different height shoes on pelvic floor function and to analyze the influencing factors.

Methods: This was a population-based, cross-sectional study performed in general hospitals with a pelvic floor subspecialty in some cities of China. All participants completed a Urogenital Distress Inventory (UDI-6) questionnaire that consisted of demographic data, information about wearing shoes, and information about pelvic floor function (UDI-6). One-way ANOVA was carried out to compare the differences among 4 groups according to the heel height (<3, 3–5, 5–7, and >7 cm groups). Multivariate logistic regression was performed to identify the factors influencing the effect of wearing 3–5 cm high-heeled shoes on pelvic floor function.

Results: In total, 1,263 participants finished the questionnaire and full data were collected. The 4 groups were comparable for clinical data, and participants who wore 3–5 cm high-heeled shoes had the lowest UDI-6 scores. Multivariate analysis revealed that the number of hours (≥8 h) wearing high heels per day and the thickness diameter (≥3 cm) of the heel were important factors affecting the protective effect of wearing 3–5 cm high-heeled shoes on pelvic floor function.

Conclusions: Wearing heeled shoes with a 3–5 cm heel height and ≥3 cm thickness for a long period of time is good for the pelvic floor function of women.

Keywords: Pelvic floor dysfunction (PFD); high heel; pelvic floor muscle training (PFM training)

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Introduction

Pelvic floor dysfunction (PFD) describes the medical situations related to changes within the pelvic floor, including urinary incontinence, bladder and bowel disorders, pelvic organ prolapse, sexual dysfunction, and pelvic pain (1). These conditions are widely predominant, particularly among females, and have an impact on quality of life and have important socioeconomic implications (2). The female pelvic floor is a complicated unit responsible for numerous functions besides pelvic organ support. It consists of all the structures in the bony pelvis: the pelvic floor muscles (PFMs), connective tissues, nerves, blood vessels,

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and urogenital and anorectal viscera (3). The PFMs form a diaphragm that spans the whole pelvic hollow space and incorporates the coccygeus and levator ani muscle groups. The levator ani muscle provides support to all of the pelvic floor organs and is transversed by the urethra, vagina, and anus. Because the levator ani muscles provide support to all 3 organ systems, their weakness will result in impaired function of any, or all, of the structures that the muscles support. The levator ani muscles consist of type I muscle fibers, which maintain the constant muscle tone necessary to keep the urogenital hiatus closed (4). Notably, the activity of PFMs can be influenced by different body positions and lumbopelvic posture (5,6).

Wearing high heels is a common habit in women to appear slender and taller. It is reported that 37–69% of ladies prefer to wear high-heeled shoes daily (7). However, wearing high heels may cause several deleterious effects on the back, knees, and lower leg pain (8). In addition, high heels can impact foot arches. Because high heels cause tendons to weaken and do not properly support the feet, women who wear high heels are at risk, especially those who spend extensive amounts of time standing up (9,10). Moreover, as heel height increases from 3 to 7 cm, peak pressure and shear stress have been found to shift from the lateral to the medial forefoot during both standing and walking (11). Due to the potential consequences of slips and falls, it is recommended that the best heel height for the maintenance of balance is from 3 to 5 cm (12-14), which is a comfortable height with a good impact on women's appearance. In addition, wearing high-heeled shoes is found to have an impact on the rotational motion of the ankle complex during walking (15), and different ankle positions can alter PFM activity (16). The association between wearing high heels and pelvic floor function has not been fully clarified. Additionally, whether a heel height of 3 to 5 cm is protective to women's pelvic floor is largely unknown.

Given the influence of high-heeled shoes on ankle position and the association between ankle position and PFM activity, it is of significance to investigate the effect of different heights of shoes on PFM activity. The objectives of this study were: (I) to evaluate the effects of wearing shoes with different heel heights on PFM function using population-based questionnaire research; and (II) to analyze the factors influencing the effects of wearing 3-5 cm high-heeled shoes on PFM function. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/tau-21-486).

Methods

Study design

This was a population-based, cross-sectional study performed in general hospitals with a pelvic floor subspecialty in some cities of China, including Shanghai First People's Hospital, Shanghai Fifth People's Hospital, Renji Hospital, Huadong Hospital Affiliated to Fudan University, Changhai Hospital, and the First Hospital of Shanxi Medical University. The inclusion criteria were age ≥18 years and female. The exclusion criteria were limp, pelvic surgery history, and cognitive impairment.

All participants who met the above criteria were interviewed to complete a questionnaire that consisted of 3 parts: (I) demographic information: age, height, weight, parity, and delivery pattern; (II) information about wearing shoes: how many times do you wear heeled shoes per week? How many hours do you wear heeled shoes per day? What is the height of the heel that you regularly wear? What is the heel thickness (the maximum diameter of the heel in contact with the ground) that you regularly wear? (III) information about pelvic floor function: Urogenital Distress Inventory (UDI-6) is a validated 6-item questionnaire that evaluates lower urinary tract symptoms in women (17). The UDI-6 provides a score ranging from 0-100, with a higher score reflecting a greater severity of symptoms. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Review Board of The Fifth People's Hospital of Shanghai, Fudan University (No.: WY-2020-139) and written informed consent was obtained from all patients.

Statistical analysis

Descriptive data were provided for the all participants and per group. Statistical analyses were performed using SPSS Statistics 25 (SPSS Inc., Chicago, IL, USA). Categorical variables were displayed as n (%). Quantitative data were shown as mean ± standard deviation (SD). One-way ANOVA was carried out to compare the differences among multiple groups. Multivariate logistic regression was performed to identify the important factors influencing the effect of wearing 3–5 cm high-heeled shoes on pelvic floor function. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for estimation. A value of $P<0.05$ was considered statistically significant.

Table 1 Clinical characteristics of all participants

Characteristics	Data
Age (years)	39.61±11.37
20–29	206 (16.31)
30–39	619 (49.01)
40–49	164 (12.98)
50–59	146 (11.56)
≥60	128 (10.13)
BMI (kg/m^2)	22.24±3.45
Underweight (<18.5)	199 (15.76)
Normal (18.5–23.9)	684 (54.16)
Overweight (24–27.9)	324 (25.65)
Obese (>28)	56 (4.43)
Parity (n)	
0	101 (8.00)
1	646 (51.15)
2	458 (36.26)
≥3	58 (4.59)
Delivery pattern	
Nulliparous	101 (8.00)
Vaginal delivery	827 (65.48)
Cesarean section	335 (26.52)

Results

In total, 1,263 participants finished the questionnaire and full data were collected. The clinical characteristics are presented in *Table 1*. The age was 39.61±11.37 years and BMI was 22.24±3.45 kg/m^2.

Because 3–5 cm is the best heel height for the maintenance of balance, the participants were divided into 4 groups according to their heel height: <3, 3–5, 5–7, and >7 cm groups. As shown in *Table 2*, 427 (33.80%), 477 (37.77%), 246 (19.48%), and 113 (8.95%) participants wore shoes with heel height <3, 3–5, 5–7, and >7 cm, respectively. Compared to participants in the 3–5 cm group, the participants in the <3 cm group were older (P<0.05), but there was no significant difference in age in the participants in the 5–7 cm and >7 cm groups (P>0.05). Meanwhile, only the BMI of participants in the <3 cm group was higher than that of the 3–5 cm group (P<0.05). No significant differences existed in parity among the 4 groups (P<0.05). These data indicated that the 4 groups were comparable for clinical data. Notably, the UDI-6 score of participants in the 3–5 cm group was the lowest among the 4 groups with a significant difference (P<0.05), indicating that wearing 3–5 cm high-heeled shoes might be protective for pelvic floor function. We then analyzed the factors influencing the effects of wearing 3–5 cm high-heeled shoes on pelvic floor function, including the number of days wearing high heels per week, the number of hours wearing high heels per day, and heel thickness (diameter). The results demonstrated that wearing 3–5 cm high-heeled shoes more than 8 h per day (8–12 h, OR: 3.238, 95% CI: 1.520–6.899, P=0.002; >12 h, OR: 2.734, 95% CI: 1.252–5.968, P=0.012) and heel thickness (diameter) ≥3 cm (3 cm, OR: 2.590, 95% CI: 1.115–6.020, P=0.027; >3 cm, OR: 2.968, 95% CI: 1.210–7.280, P=0.017) were protective factors for pelvic floor function (P<0.05) (*Table 3*).

Discussion

With the change in aesthetics, many young women want to look taller and more fashionable, preferring to wear high-heeled shoes during their daily lives. However, wearing high-heeled shoes with an excessive focus on design or fashion may increase the risk of falls and result in various musculoskeletal disorders and deformities (18,19). In addition, wearing high-heeled shoes influences the rotational motion of the ankle complex during walking (15), and the ankle position is found to be related to the pelvis inclination and PFM activation (16). Whether there is an association between wearing high heels and PFM activity has not been fully investigated.

In the present study, we investigated the influence of wearing shoes of different heights on pelvic floor function evaluated by the UDI-6 score, and analyzed the potential risk factors affecting pelvic floor function, such as the length of time heeled-shoes are worn and the thickness diameter of the heels. Our results showed that the 4 groups were comparable for clinical data, and wearing 3–5 cm high-heeled shoes might be protective for pelvic floor function. Furthermore, multivariate analysis revealed that the number of hours (≥8 h) wearing high heels per day and the thickness diameter (≥3 cm) of the heel were related to a significantly lower UDI-6 score. To our knowledge, this is the first study with a large sample size (1,263 female participants) for the analysis of the effect of wearing high heels on PFM function in a population-based survey. Our findings will provide reliable data to guide clinical practice.

Table 2 Clinical characteristics of participants in different heel height groups

Characteristics	<3 cm	3–5 cm	5–7 cm	>7 cm
Patients, n (%)	427 (33.80)	477 (37.77)	246 (19.48)	113 (8.95)
Age (years)	39.69±11.36*	38.29±10.33	36.29±8.83	36.61±8.73
BMI (kg/m^2)	22.26±3.45*	21.83±3.07	22.41±3.64	21.27±3.26
Parity (n)	1.38±0.70	1.37±0.76	1.25±0.59	1.33±0.56
UDI-6 score	28.68±21.21*	19.90±17.49	33.25±18.36*	32.79±20.94*

*, indicates P<0.05 when compared to the 3–5 cm group.

Table 3 Multivariate logistic regression for the factors influencing the effect of wearing 3–5 cm high-heeled shoes on pelvic floor function

Variables	n/total	OR (95% CI)	P value
The number of days wearing high heels per week			
<1 d	10/477	1.00	
1–2 d	208/477	0.521 (0.119–2.275)	0.386
3–4 d	124/477	1.012 (0.230–4.459)	0.988
>4 d	135/477	1.023 (0.232–4.513)	0.976
The number of hours wearing high heels per day			
<2 h	73/477	1.00	
3–5 h	135/477	1.090 (0.059–2.243)	0.815
6–8 h	130/477	1.226 (0.598–2.514)	0.578
8–12 h	73/477	3.238 (1.520–6.899)	0.002
>12 h	66/477	2.734 (1.252–5.968)	0.012
Heel thickness (diameter)			
1 cm	47/477	1.00	
2 cm	184/477	1.313 (0.558–3.091)	0.533
3 cm	161/477	2.590 (1.115–6.020)	0.027
>3 cm	85/477	2.968 (1.210–7.280)	0.017

PFM function plays a decisive role in maintaining urinary continence and pelvic organ support (20). PFMs are composed of 70% slow-twitch (type I) and 30% fast-twitch (type II) fibers (21). Type I muscle fibers are primarily responsible for PFM endurance, and maintain the constant muscle tone necessary to keep the urogenital hiatus closed (4). Although they fatigue faster than type I fibers, type II fibers are primarily responsible for PFM strength and power, which prevent urinary leakage during sudden actions (22). PFMs are revealed to impact important functions in urethral closure at rest and the intraabdominal pressure increases during exertion (e.g., sneezing or exercise) (23). PFM training is widely used for the treatment and prevention of PFD (24), and the possible mechanisms are: (I) that women develop a "knack" for consciously contracting PFMs before and during abdominal pressure increases during exertion, and (II) that strengthening the PFMs can establish the structural support to the pelvic floor (25). In our study, wearing shoes with a 3–5 cm heel height and ≥3 cm thickness for more than 8 h per day, including walking, standing, and sitting positions, might be an approach for PFM training: when PFMs contract, it causes the inhibition of detrusor overactivity; when the PFMs and the external sphincter of the urethra contract,

the relaxation of the internal sphincter of the urethra is inhibited, and urine cannot enter the posterior urethra, thus terminating urination. This may be a potential mechanism regulating the protective effect of wearing high heels on pelvic floor function.

In addition, the pelvic tilt angle caused by the change in ankle movement is an important factor influencing PFM activity (26,27). When wearing heeled shoes, the ankle is unstable plantar flexion and may result in greater PFM activity in the standing position. With high-heeled shoes, the pelvis tilts more posteriorly, inducing a compensatory posture with gluteal contraction (28). It suggests that PFM contraction in active ankle positions results in the simultaneous use of abdominal, back, thigh, and leg muscles to maintain posture. The co-activation of abdominal muscles and the pelvic floor is of importance in PFD and should be considered in rehabilitation programs. Chen *et al.* demonstrated that an upright standing posture with the ankles dorsiflexed could facilitate anterior pelvic tilt, which in turn increased effective PFM activity to its greatest point (29). Moreover, it has been suggested to use various ankle positions to try to improve the success rate of PFM training (30). The ankle position induced by wearing high-heeled shoes might have an impact on PFM activity due not only to the posterior pelvic tilt but also the higher impact force transmitted to the PFMs (31). Notably, changes in the distribution of foot pressure and displacement of the center of pressure were not significantly altered after walking in middle-heeled (4 cm) shoes, but were remarkably altered after walking in either flat (0.5 cm) or high-heeled (9 cm) shoes, confirming that middle-heeled (4 cm) shoes are good for the health and comfort of the feet (32). In this study, we enrolled a larger number of patients and found that wearing 3–5 cm high-heeled shoes was related to a significantly lower UDI-6 score, which may explain why 3–5 cm height may be suitable for ankles, pelvis, and spine. Moreover, Lee *et al.* reported that heel thickness is related to walking stability (33). Our results showed that heel thickness (diameter) ≥3 cm was a protective factor for pelvic floor function, which may be associated with a relatively stable plantar flexion caused by good stability. However, our results were not consistent with previous findings that no significant link was identified among wearing high heels, anal canal pressure values, and the severity of fecal incontinence by the Wexner scale (34). More studies are still required to confirm our findings.

There are also some limitations meriting further consideration. One limitation of this study was that pelvic floor function was only evaluated by collecting the UDI-6 questionnaire from participants. More objective measurements should be taken, such as PFM strength (Modified Oxford Scale), intrapelvic surface electromyography of PFMs, and ultrasound imaging of the pelvic floor. Another limitation was that we only collected data on the time that women wore heeled shoes, and it was not clear that they spent most of their time standing or sitting. Because body position is also an important factor influencing PFM function (6,35), collecting the accurate time wearing heeled shoes in the standing position may be more meaningful than the method in the current research.

Conclusions

This study showed that wearing shoes with a 3–5 cm heel height and ≥3 cm thickness for more than 8 h per day was protective for the pelvic floor function of women. Because pelvic tilt may vary according to age and the habit of walking with high heels, further studies are necessary.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://dx.doi.org/10.21037/tau-21-486

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki

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