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ORIGINAL RESEARCH **PAIN MANAGEMENT**

Association of low back pain with the use of high heel in ladies: a systematic review

Ali Shehvaiz Younas[1], Fahad Tanveer[2], Faiza Sharif[3], Iqra Waseem[4], Wajeeha Mahmood[5], Ashfaq Ahmad[6]

Author affiliations:

1. Ali Shehvaiz Younas, DPT, MPPTB, Consultant PT, Reactive Physio Clinic, Lahore, Pakistan; E-mail: shehvaizch@gmail.com; ORCID: {0000-0002-5465-4902}
2. Fahad Tanveer, MSMSK, DPT, Assistant professor, University Institute of Physical Therapy, The University of , Lahore, Pakistan; E-mail: fahad.tanveer@uipt.uol.edu.pk; ORCID: {0000-0002-8877-0370}
3. Faiza Sharif, BSPT, M,phill, PHD, Assistant professor, University Institute of Physical Therapy, The University of Lahore, Pakistan; E-mail: faiza.sharif@uipt.uol.edu.pk; ORCID: {0000-0002-9186-858X}
4. Iqra Waseem, PT, DPT, MS (MSK), Assistant Professor, University Institute of Physical Therapy, University of Lahore, Lahore, Pakistan; Email: iqra.waseem91@gmail.com; ORCID: {0000-0002-1487-7749}
5. Wajeeha Mahmood, BSPT, MSNMPT, PhD scholar, Assistant Professor, The Superior University, Lahore, Pakistan; E-mail: wajeeha.mahmood@superior.edu.pk
6. Ashfaq Ahmad, UIPT, FAHS, Professor, University of Lahore, Lahore, Pakistan; E-mail: ashfaaqpt@gmail.com; ORCID: {0000-0002-1965-6224}

Correspondence: Ali Shehvaiz Younas; E-mail: shehvaizch@gmail.com; Phone: +923134142899

ABSTRACT

Background & Objective: High heels of shoes are preferred for attractiveness, but are detrimental to health regarding their biomechanics. High heel changes the joint mechanics during walking which may result in abnormal stress and pressure at certain points and thus lead to painful knee, foot, hip or low back pain. The objective of this systematic review was to evaluate the literature addressing the association between the high heeled shoes and low back pain among females.

Methodology: It was a systemic review conducted during 2014-2020 on databases including Cochrane Library, PubMed, Medline, PEDro and Scopus, with key words 'Low back pain' OR 'Back pain OR Lumbago', 'Low back pain in females OR Back pain in females OR Lumbago in females', 'High heeled shoes OR High heels', 'Association OR relationship'. Available full-length papers in English language were explored, after the screening and quality assessment using Axis critical appraisal tool for the studies.

Results: We found 32 articles, but the inclusion criteria were met only by 11 studies in quality score of 16. 27/20. The eligible studies enrolled a total of 1334 female participants with an average age of 18-32 y. Nine studies explained that low back pain was associated with high heeled shoes but none specified height of the heel, and only a range of 2.5-11 cm was suspected to be associated with changes in lumber biomechanics or lordosis, that can exert extra pressure for postural adjustments and lead to low back pain.

Conclusion: Out of 11 studies, nine studies favored that low back pain was associated with high heeled shoes, there was no specific height mentioned; but only a range of 2.5-11 cm was found to be associated with biomechanical changes due to postural adjustments, being a possible cause of low back pain among females.

Key words: Association; Females; High Heel; Low Back Pain; Shoes

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1. INTRODUCTION

Low back pain (LBP) refers to pain in the lumbar spine region due to abnormal stress and strain placed directly on the spine involving the intervertebral disc, muscle, ligaments, and other related soft tissues in the spine.[1] High heeled shoes are the term used for a heel more than the height of the forefoot and may exceed up to a height of 10 cm, with a small and narrow toe box, a firm or rigid cap, and curved shaped plantar region, the combined effect of all these can affect the motion of foot during the walking. High heeled shoes, a fashion for decades, along with a set of precautionary measures, but they remained popular in every era of fashion among every society.[2] LBP is believed to be caused by the use of high heels and healthcare providers think that lumbar lordosis can be a source of change in the curve of the spine. An estimated 78% of the women use high heels in their daily life but among this 58% reported that they had LBP,[3] and 55% women felt discomfort with heel size of about 6-9 cm.[4] Russel stated that lumber lordosis is not effected by high heeled shoes but it was only likely due to standing posture only.[5] The basic mechanism that is thought to be involved with walking with high-heels is an increase in the knee joint extensor movement because of bone-on-bone forces.[6]

According to the biomechanical point of view, the gravity lines displacement during walking wearing high heeled shoes, a greater compensatory mechanism during the planter flexion, pelvis and trunk movements to the posterior of the body is required.[4] Prolonged standing can cause musculoskeletal discomfort in these ladies because of a sustained posture with abnormal mechanics of spine. In addition to low back and leg pain, some of the reports have shown joint degenerative disease as well.[7] Because of high heeled shoes, trunk muscles have to work more in order to maintain the balance of body mass and center of gravity. Studies have found that as the heel height increases, it can proportionally disturb the body balance, trunk stability, activation of muscles of ankles and knees, and of cervical and lumbar spine. The reason behind these changes is the adjustment of trunk for reduction of any tilt of the body and the hyperextension of the hip because of the pelvic tilt on posterior side. The most important point to be taken in consideration is the adjustment of the body during the movements.[4] The flat sandals can be a source of pain and most effected region reported has been back (9.9%) in 87 females. But this study stated that pain was reported in both flat as well as high heeled foot wearing females.[8] Different physiologic techniques had associated gait pattern and its changes with heel height. Low heel is energy efficient and induces less fatigue compared to high heeled shoes. The reason behind it is reduction in voluntary muscle contractions and reflexes and timing of movement onset.[9] As compared to flat soles, high heel shoes have been reported to result in an increase in vertical and anterior–posterior ground reaction force (GRF), that ultimately can affect the lumber spine.[10] Another study reported correlation of high heeled shoes and imbalances of body among female college students. Low back frequency was correlated with right leg length but negative correlation between left foot and back pain.[11] Franklin found that positive heels are better than zero heel inclination angle and cause a decrease in lumber lordosis, sacral tilt angle and anterior pelvic tilt in comparison to zero heel height.[12]

Brent Russel and colleagues found stilettos do not influence lumber angle. Low backache endorsed to heels can be due to factors other than increased lumber angle.[13] The literature has inconsistent findings about the effects of high heeled foot wear special on the pelvic tilt, sacral tilt and angle of lumber lordosis. But, medium size of heels caused a reduction of vertical balance and inclination of pelvis with significant effects. The dominant effects were seen in the lordosis angle and kyphosis among the participants in young females in standing position.[14] Heel lifts can change the activity of muscles, but despite all these, a minimum number of studies discussed the mechanism of high heels and muscles of the back during walking or assessed the gait parameters.[15] The data availability is insufficient to suggest ambulation with a high-heeled shoe and alteration of muscles activities like erector spinae during the movements.[16] In a recent survey the Pearson correlation coefficient was 0.063, indicating a weak relationship with no statistical significance between high heel shoes and low back discomfort.[17] Hsue et al. stated that women used to wear high heel shoes for almost 1-8 h daily. Nguyen et al. pointed out that width considerations were important during the design formulation of shoes especially the front part as well as the thickness of the sole.[18] Perera et al. considered formulation of gender-based design according to biomechanical factors and following the shape of feet in women and men's but quality features should not be variants.[19] Zostawa et al. stated that negative changes start during the gait cycle as high heels lead to smaller dorsiflexion.[20] This calls for additional concern when selecting shoes. However, Lorkowski et al. stated that women who were active in their professional work, have to follow the organizational dress code and the shoes according to the demand of the job, wear high-heeled shoes at their job working hours. This can put undue stress on the lumbar spine leading to LBP.[21]

Previous studies have not addressed with certainty, the association of high heels with LBP. The basic aim of this systematic review was to target on the association of LBP with high-heeled shoes. The study will be helpful to find the association, which might help the clinicians

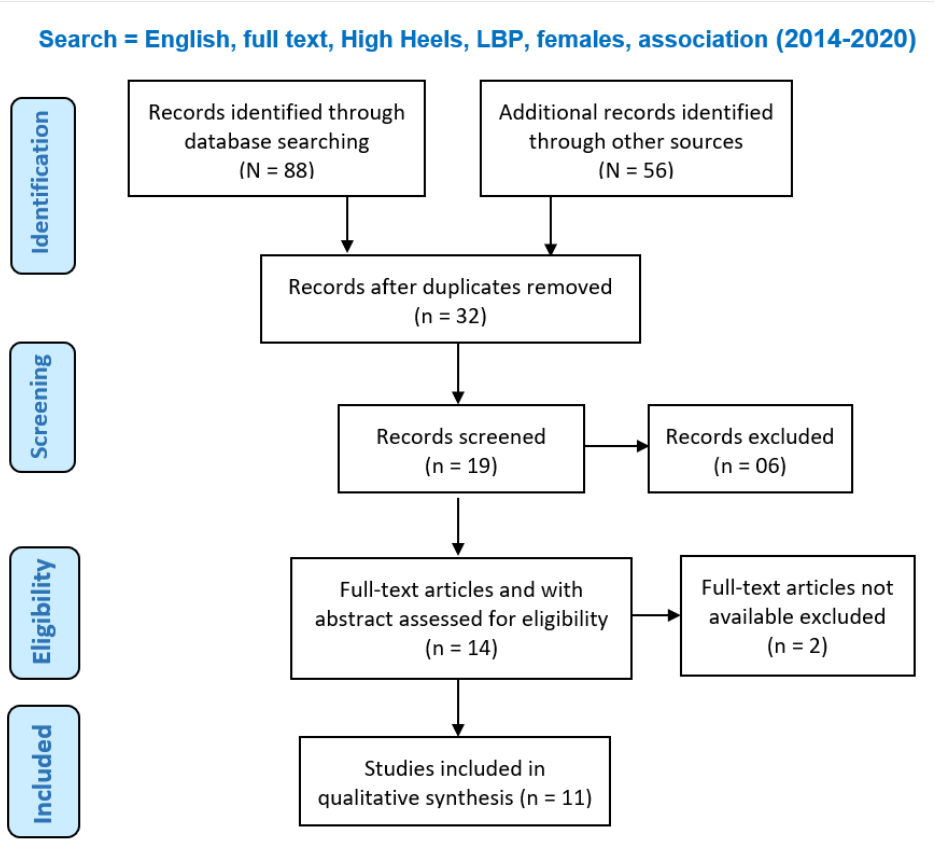

Figure 1: Flow Chart of Data Inclusion Strategy for Systematic Review

to consider the foot mechanics involved in musculoskeletal disorders specifically low back among the females.

2. METHODOLOY

2.1. Search strategy

The literature search was conducted in Cochrane Library, PubMed, Medline, PEDro and Scopus databases. The search was conducted using key words: 'Association of LBP', 'high heels', and 'Footwear's for females'. The strategy was: 'LBP' OR 'Back pain OR Lumbago', 'Low back pain in females' OR 'Back pain in females' OR 'Lumbago in females' and 'High heeled shoes' OR 'High Heels' OR 'Footwear And Association OR relationship'. This systematic review was completed in 9 months.

2.2. Eligibility criteria

All studies addressing LBP, back pain or lumbago, having an association, link or relationship with LBP among females due to high heeled shoes were included. The custom range was followed during the search of the databases.

We included case studies; cross-sectional studies and prevalence studies were included and crossover trials if outcome data was available for each intervention prior to the crossover in custom range of 2014 to 2020. We excluded studies published in languages other than English, reviews, short reports, or any other trials involving participants with secondary dysmenorrhea, identifiable pelvic pathology or chronic pelvic pain, LBP caused by specific pathologies or conditions, trials using insoles to treat limb length discrepancy (LLD) and pelvic obliquity, as there is disagreement regarding whether LLD does predispose to musculoskeletal disorders and what magnitude of LLD is pathological.[22] Clinical trials, randomized or quasi-randomized, where analgesics were also used, not freely available in full length text, musculoskeletal disorders including effects on gait, foot deformities, sacroiliac joint etc. duplicate records/studies and non-eligible studies were excluded.

2.3. Sample size

A total of 32 relevant articles were identified through searches on the databases; and 19 of these were screened. Six studies were eliminated due to irrelevant results or outcomes like knee, hip pathology. There were 13 studies that completely met the inclusion criteria, but two of these were not available for full access so not included in the review. The final sample size for the review came out to be 11, the details of which are given in the results section (Table 1).

2.4. Quality assessment

The AXIS tool is a critical appraisal tool that addresses study design and reporting quality as well as the risk of bias in a cross-sectional study, which was developed in 2016. All potentially appropriate articles were selected for eligibility and those adequate records were assessed for methodological quality using the critical appraisal (CA) AXIS tool. It has 20 items related to different

parameters of articles including objectives, methodology, results and discussion of the specific outcomes presented in article in a logical way. The appraisal tool has areas to record a 'yes', 'no' or 'don't know' answer for each question and there is room for short comments as well.[23]

2.5. Assessment of risk of bias

The articles were searched by one investigator based on the inclusion and exclusion criteria and a second investigator had to make a second round to search the articles. A consensus method was made to resolve disagreements and a third review author was consulted where disagreement persisted. If the authors could not be contacted, or if the information was no longer available, the criterion will be scored as 'unclear'. The Cochrane risk of bias tool from the 'Cochrane Handbook for Systematic Reviews of Interventions' was used to assess the risk of bias. All criteria were scored as 'low risk', 'high risk', or 'unclear'.

2.6. Data extraction

The study data was extracted independently using a data extraction form. The records regarding author, year, country, study design, aim of the study, size of high heeled shoes, mean age of participants, reported results, association with LBP and P-values mentioned in the results were extracted. The conflict between the assessors was resolved by the third reviewer if there was any such conflict that came across. Relevant information from the included studies was extracted and reviewed by the authors.

2.7. Data analysis

The variety of research regarding pain, pain intensity, and association, size of high heels in different studies, and different methods of pain measurement, was not allowing the quantitative analysis. The extracted data were presented individually in the tabloid form in the given tables in the results section.

2.8. Ethical considerations

All the all data used are available publicly on different databases. So ethical approval was not required for this study.

3. RESULTS

After the screening of studies according to the criteria of the review, duplicate records, and outcomes of interest and we found 11 studies with full-text availability in the English language aimed to find Low back in women wearing high heels. According to AXIS appraisal tool, Our 11 eligible studies ranged in a score of 16.27/20. All the eligible studies have enrolled 1334 female participants with an average age 18-32 y. The average high heel size was different in different studies minimum 2.5 cm and a maximum was 7-11 cm height of heel was used by participants of included studies. Secondly, 02 studies, Lee M and Hadeel had not mentioned specific height in their studies.[24,25] Regarding LBP its association Rizky A stated no any association to LBP but was working time period associated with even the heel height was more than 5 cm.[26] Jan Schroeder study was in favor of no association because he stated that there is no effect on lumbar lordosis or ROM or even in dynamic conditions.[27]

Remaining nine studies stated that low back high heeled shoes wearing women had back discomfort. But Younus stated 40.2% low back among $\geq$ 2.5 cm high heel wearing women and Hadeel stated it associated with F= 0.05 Basha found in 60% of the participants but only in long term users.[28] Nawaz U had found only 23 % back pain with P = 0.000 with 2 cm flat scandals and stiletto to high 5 cm heels.[8] But Kashif M , targeted woman wearing high heels of $\geq$ 5 cm size found LBP with P = 0.000 and 9.9 % had LBP in studies by Qureshi M with same heel size.[29,30]

4. DISCUSSION

This review found 11 studies with full-text availability in English language aimed to find low back pain in women wearing high heels. Our 11 eligible studies ranged in the score of 16. 27 /20. All the eligible studies enrolled 1334 female participants with an average age 18-32 y. The average high heel size was different in different studies; 2.5 cm to a maximum of 7-11 cm height of heel was used by participants of the included studies. The details can be seen in table along with other details of participants. Secondly, two studies, did not mentioned specific heights in their studies.[24,25] One of the studies found that as the size of high heels increases from 7-10 cm there was more discomfort, directional control and maximum excursion. These compromised functional mobility and maintenance of the balance. The main reason was an increase in muscular effort and it was labelled as worse standing posture while wearing up 10 cm heels.[34] According to Bahrizal AR et al., high heels had no association with LBP, but it was the working time period which was associated with even the heel height of more $\geq$ 5 cm.[26] Similar , Cowley EE et al. have stated that discomfort can be due to magnitude of the vertical ground forces in women who wear high heeled shoes, because a loss of lumbar lordosis leads to an increase in compression of IVD in axial direction activation of erector spinae muscles that compresses the spinal column.[35] A study by Schroeder J et al. was in favor of no association because they stated that there was no effect on lumber lordosis or ROM or even in dynamic

Table 1: Studies included in review and their outcomes

No.	Author/Year of study	Objective	Study Type	Sample Size /age (y)	Size of Heel	Association	Results
1.	Younus SM 2014 [32]	Wearing high heels and its outcomes in young generation	Cross sectional study	220 15-25 y	≥2.5 cm	Not Reported	40.2% has LBP
2.	Hadeel AL 2015 [25]	High heeled shoes and its effect on LBP and disability	Cross sectional	312 32.68 ± 8.04 y	unclear	0.05[f]	Low back was associated with high heeled shoes wearers compared to flat shoes
3.	Adhika Rizky 2017 [26]	Evaluate LBP and its association with high heels	Cross sectional	123 20-40 y	≥5 cm	None found with LBP	High heels were not found associated to LBP but was associated with working time period
4.	Basha 2018 [28]	To study physiological effects of High heels	Cross sectional	115 >15	>4 cm	NA	60% of the participants experienced back pain but they were long term users
5.	Jan Schroeder 2018 [27]	To find effects of high heels on lumbopelvic rhythm in middle aged woman	Randomized cross over	37 18-56 y	7-11 cm	>0.05	No effect on lumber lordosis or ROM or dynamic conditions were reported
6.	Nawaz U 2019 [8] Pakistan	To find out musculoskeletal pain among the females with different heels size foot wears.	Cross Sectional	87 18-32 y	2 cm flat scandals Stiletto High heels 5 cm	0.000*	23% had effected their back due to high heels compared to flat shoes
7.	Kashif M Pakistan 2019 [30]	To find association between high heels and LBP	Cross sectional	50 21.1 mean age	≥ 5 cm	0.001	Pain was reported among females who wear it for more than 2 y
8.	Qureshi Muhammad [29] 2019 Pakistan	To determine lower back and calf muscles pain due to high heels	Cross sectional	87 18-32 y	5 cm stiletto heels	0.000	9.9% had LBP
9.	Guren HG 2020 [31] Turkey	To measure discomfort while wearing high heeled shoes	Cross sectional	40 30.95 ± 5.85	5 cm	67.5% pain at rest 50% during movements	P = 0.05
10.	Lee M 2020 [24]	High heels and body imbalance	Cross sectional	89	unclear	P < .05	High heeled shoes caused LBP
11.	Malick WH 2020 [33] Pakistan	To determine association of high heeled shoes with musculoskeletal discomfort	Cross sectional	174	6.35 cm (2.5 inches)	No proven association	There was an association of upper back and shoulder discomfort with length of shoes

systematic review conducted by Silva A et al. retrieved

Table 2: Critical Appraisal using AXIS tool

AXIS Tool Items No.	Kashif M 2019 [30]	Adhika Rizky 2017 [26]	Guren HG 2020	Lee M 2020 [24]	Basha 2018 [28]	Younus SM 2014 [32]	Nawaz U 2019 [8]	Jan Schroeder	Hadeel AL 2015	Wardah Hussain Malick	Qureshi Muhammad [29]
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3	N	N	Y	Y	Y	N	N	Y	N	Y	N
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6	Y	D	Y	Y	Y	Y	N	Y	Y	Y	Y
7	N	D	Y	Y	Y	N	N	N	Y	D	Y
8	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
9	D	Y	Y	Y	D	N	D	Y	Y	Y	N
10	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
11	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
13	N	D	N	Y	Y	N	N	N	N	Y	Y
14	N	Y	Y	N	N	N	N	Y	Y	Y	Y
15	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
16	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
18	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y
19	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y
20	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y
Total Scores (20)	**14**	**16**	**17**	**19**	**18**	**11**	**13**	**19**	**15**	**19**	**18**
Mean score										179/11	Average = 16.27/20
Y = Yes (1) N = No (0) D = Don't Know (0)											

conditions.[27] Another review was based on 14 studies about the high heels and lumbar lordosis in association with LBP. The conclusion was made that high heeled shoes have not any effect on lordosis in standing, despite it decrease lumber lordosis. They further claimed that a reduced lordosis, adjustment of the posture and pelvic retroversion can be a contributing factor that develop a stress on the lumber spinal segment and lead to precipitate the LBP.[36] Nine studies stated that high heeled shoes wearing women had low back discomfort. Another author stated 40.2% low back among $\geq$ 2.5 cm high heel wearing women and Hadeel AL stated it associated with P = 0.05. Basha FYS et al. found it in 60% of the participants but only in long term users.[28] Nawaz U, et al. found only 23% back pain with P = 0.000 with 2 cm flat sandals and stiletto with 5 cm heels.[8] The 55 articles; 20 articles were included in analysis after the exclusion criteria. The final conclusion was made by them that postural disorders can be due to high heeled shoes, forward head, hyperlordosis at lumber with anteversion of pelvis in addition to genu valgus are the major outcomes. But still the considerable factors were the imbalance and changes in posture due to width and height of high heels.[37] But Nadeem I et al. targeted woman wearing high heels of $\geq$5 cm size found LBP with P = 0.000 and 9.9 % had LBP in studies by Qureshi MY et al. with same heel size,[29, 30] and 67.5% ladies had LBP with same heel size.[24,31] The main reason was that high heeled shoes caused flexion of knees, lumber lordosis along with cervical lordosis which changes the center of gravity, this is considered as the mechanism of pain in different regions of the body especially in knees and lower back and to some extent in the neck.[38] Now

the main consideration is that high heeled shoes do not change lumber mechanics but cause LBP due its prolonged use.[39]

5. LIMITATIONS

There were many studies that had addressed high heeled shoes and the biomechanics of spine, hip, pelvis and knee. Very limited studies were available that specifically targeted LBP. This may have undesirable outcomes that may affect the findings of the review. This review has excluded all the studies that did not offer free full access. Some of the studies had not directly addressed the LBP. The variety of the data in the articles makes it difficult to extract the outcomes.

6. PRACTICAL IMPLICATIONS

There should be cross-sectional studies, addressing high heeled shoes and biomechanical changes and proper evaluation with standard measurement procedures to associate different levels of discomfort among women. This should be part of prevention strategies to avoid the use of high heeled shoes.

7. CONCLUSION

The systematic review was aimed to retrieve the evidence about association of high heeled shoes with low back pain in ladies. Our 11 eligible studies ranged in quality score of 16.27/20. All the eligible studies enrolled 1334 female participants with an average age 18-32 y. Out of 11 studies based on criteria, 9 favored that low back pain was associated with high heeled shoes; although there was no specific height but only a range of 2.5-11 cm was thought to be associated with change in lumber biomechanics or lordosis that can exert extra pressure due to postural adjustments and cause low back pain.

7. Data availability

The numerical data generated during this research is available with the authors.

8. Acknowledgement

We gratefully thank Faculty of Medicine.

9. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

10. Authors' contribution

SS: Concept and design, Collection and assembly of data

RN, IW: Analysis and interpretation of the data and Critical revision of the article for important

AS: Literature search, assembly of data

WM: Critical revision of the article for important intellectual content: Statistical expertise.

TM: Drafting of the article, Final approval and guarantor of the article, Statistical expertise

11. REFERENCES

1. Will JS, Bury DC, Miller JA. Mechanical Low Back Pain. Am Fam Physician. 2018 Oct 1;98(7):421-428. [PubMed]
2. Lemont H, Ammirati KM, Usen N. Plantar fasciitis: a degenerative process (fasciosis) without inflammation. J Am Podiatr Med Assoc. 2003 May-Jun;93(3):234-7. [PubMed] DOI: 10.7547/87507315-93-3-234
3. Baaklini E, Angst M, Schellenberg F, Hitz M, Schmid S, Tal A, et al. High-heeled walking decreases lumbar lordosis. Gait Posture. 2017 Jun;55:12-14. [PubMed] DOI: 10.1016/j.gaitpost.2017.03.035
4. Bendix T, Sørensen SS, Klausen K. Lumbar curve, trunk muscles, and line of gravity with different heel heights. Spine (Phila Pa 1976). 1984 Mar;9(2):223-7. [PubMed] DOI: 10.1097/00007632-198403000-00016
5. Russell BS, Muhlenkamp KA, Hoiriis KT, Desimone CM. Measurement of lumbar lordosis in static standing posture with and without high-heeled shoes. J Chiropr Med. 2012 Sep;11(3):145-53. [PubMed] DOI: 10.1016/j.jcm.2012.02.002
6. Simonsen EB, Svendsen MB, Nørreslet A, Baldvinsson HK, Heilskov-Hansen T, Larsen PK, et al. Walking on high heels changes muscle activity and the dynamics of human walking significantly. J Appl Biomech. 2012 Feb;28(1):20-8. [PubMed] DOI: 10.1123/jab.28.1.20
7. Bahrizal AR, Meiyanti M. Association Between Heel-Height and Low Back Pain in Sales Promotion Girls. J Kedokteran Dan Kesehatan Indonesia. 2017;8(3):198-204. DOI: 10.20885/JKKI.Vol8.Iss3.art9
8. Nawaz U, Hashmi MA, Qureshi MY, Qureshi AY, Minhas A, Aziz SA, et al. Prevalence of musculoskeletal pain among young females using different heel heights: a cross-sectional study. Rawal Med J. 2019;44(1):220-2. [FreeFullText]
9. White SG, McNair PJ. Abdominal and erector spinae muscle activity during gait: the use of cluster analysis to identify patterns of activity. Clin Biomech (Bristol, Avon). 2002 Mar;17(3):177-84. [PubMed] DOI: 10.1016/s0268-0033(02)00007-4
10. Rabusin CL, Menz HB, McClelland JA, Tan JM, Whittaker GA, Evans AM, et al. Effects of heel lifts on lower limb biomechanics and muscle function: A systematic review. Gait Posture. 2019 Mar;69:224-234. [PubMed] DOI: 10.1016/j.gaitpost.2019.01.023
11. Lee MW, Jeong YW. An Analysis of the Correlation between High Heels and Pain in the Low Back, Knee, Ankle and Toe, Length of Legs, and Plantar Pressure among Women in Their Twenties. J Korean Orth Manual Phys Ther. 2020;26(2):11-8.
12. Franklin ME, Chenier TC, Brauninger L, Cook H, Harris S. Effect of positive heel inclination on posture. J Orthop Sports Phys Ther. 1995 Feb;21(2):94-9. [PubMed] DOI: 10.2519/jospt.1995.21.2.94

13. Russell BS, Muhlenkamp-Wermert KA, Hoiriis KT. Measurement of Lumbar Lordosis: A Comparison of 2 Alternatives to the Cobb Angle. J Manipulative Physiol Ther. 2020 Oct;43(8):760-767. [PubMed] DOI: 10.1016/j.jmpt.2020.05.009

14. Michoński J, Witkowski M, Glinkowska B, Sitnik R, Glinkowski W. Decreased Vertical Trunk Inclination Angle and Pelvic Inclination as the Result of Mid-High-Heeled Footwear on Static Posture Parameters in Asymptomatic Young Adult Women. Int J Environ Res Public Health. 2019 Nov 18;16(22):4556. [PubMed] DOI: 10.3390/ijerph16224556

15. Barton CJ, Coyle JA, Tinley P. The effect of heel lifts on trunk muscle activation during gait: a study of young healthy females. J Electromyogr Kinesiol. 2009 Aug;19(4):598-606. [PubMed] DOI: 10.1016/j.jelekin.2008.03.001

16. Mika A, Oleksy Ł, Mikolajczyk E, Marchewka A. Evaluation of the influence of low and high heel shoes on erector spine muscle bioelectrical activity assessed at baseline and during movement. Med Rehab. 2009;13(3):9-18. [FreeFullText]

17. Atif MM, Afzal F, Rasul A, Islam A, Khan A. Association of high heeled shoes and low back pain among students who wear high heeled shoes. RMJ. 2021; 46(4): 884-886. [FreeFullText]

18. Nguyen US, Hillstrom HJ, Li W, Dufour AB, Kiel DP, Procter-Gray E, et al. Factors associated with hallux valgus in a population-based study of older women and men: the MOBILIZE Boston Study. Osteoarthritis Cartilage. 2010 Jan;18(1):41-6. [PubMed] DOI: 10.1016/j.joca.2009.07.008

19. Perera AM, Mason L, Stephens MM. The pathogenesis of hallux valgus. J Bone Joint Surg Am. 2011 Sep 7;93(17):1650-61. [PubMed] DOI: 10.2106/JBJS.H.01630

20. Zostawa P, Uścinowicz N, Klich S, Zostawa J. Kinematic analysis of gait in women wearing high heels. Med Rev. 2014(3):216-23. [FreeFullText]

21. Lorkowski J, Mrzygłód M, Kotela I, Kiełbasiewicz-Lorkowska E, Teul I. Footwear according to the "business dress code", and the health condition of women's feet--computer-assisted holistic evaluation. Ann Acad Med Stetin. 2013;59(2):118-28. [PubMed]

22. Gurney B. Leg length discrepancy. Gait Posture. 2002 Apr;15(2):195-206. [PubMed] DOI: 10.1016/s0966-6362(01)00148-5

23. Downes MJ, Brennan ML, Williams HC, Dean RS. Development of a critical appraisal tool to assess the quality of cross-sectional studies (AXIS). BMJ Open. 2016 Dec 8;6(12):e011458. [PubMed] DOI: 10.1136/bmjopen-2016-011458

24. Kogler GF, Veer FB, Verhulst SJ, Solomonidis SE, Paul JP. The effect of heel elevation on strain within the plantar aponeurosis: in vitro study. Foot Ankle Int. 2001 May;22(5):433-9. [PubMed] DOI: 10.1177/107110070102200513

25. AL Serhany H, AL Anazi F. Effect Of Prolonged Wearing High Heeled Shoes On Occurrence Of Low Back Pain (Lbp) And Disability Among Females In Al Jouf City. Int J Adv Res. 2015;3(12):1715-22. [FreeFullText]

26. Lee C. The Effects of Lower Extremity Angle According to Heel-height Changes in Young Ladies in Their 20s during Gait. J Phys Ther Sci. 2014 Jul;26(7):1055-8. doi: 10.1589/jpts.26.1055. Epub 2014 Jul 30. [PubMed] PMCID: PMC4135197 DOI: 10.1589/jpts.26.1055

27. Schroeder J, Hollander K. Effects of high-heeled footwear on static and dynamic pelvis position and lumbar lordosis in experienced younger and middle-aged women. Gait Posture. 2018 Jan;59:53-57. [PubMed] DOI: 10.1016/j.gaitpost.2017.09.034

28. Basha FYS, Devi RG, Priya AJ. A survey on comparative effects of wearing high heels among long-term and short-term users. Drug Invention Today. 2018;10(11).

29. Qureshi MY, Akbar B. A cross-sectional study determining pain in lower back and calf muscles among females due to high heel shoe wear. Health Sci. 2019;8:70-4. [FreeFullText]

30. Nadeem I, Kashif M, Mushtaq S, Hussain R, Naseem N, Darain H, et al. High Heels and Low Back Pain in Young Female Students. Int J Pathol. 2018:87-91. [FreeFullText]

31. Güren HG, Kaygısız BB, Gözgen H. Physical Activity Level and Pain Incidence in Women Wearing High Heeled Shoes. Medicina Sportivâ. 2020;26(2). [FreeFullText]

32. Younus SM, Ali T, Memon WA, Qazi A, Ismail F. High heel shoes: outcome of wearing in young generation: a cross sectional study. Professional Med J. 2014;21(04):798-803. DOI: 10.29309/TPMJ/2014.21.04.2230

33. Malick WH, Khalid H, Mehmood Z, Hussain H. Association of musculoskeletal discomfort with the use of high heeled shoes in females. J Pak Med Assoc. 2020 Dec;70(12(A)):2199-2204. [PubMed] DOI: 10.47391/JPMA.536

34. Hapsari VD, Xiong S. Effects of high heeled shoes wearing experience and heel height on human standing balance and functional mobility. Ergonomics. 2016;59(2):249-64. [PubMed] DOI: 10.1080/00140139.2015.1068956

35. Cowley EE, Chevalier TL, Chockalingam N. The effect of heel height on gait and posture: a review of the literature. J Am Podiatr Med Assoc. 2009 Nov-Dec;99(6):512-8. [PubMed] DOI: 10.7547/0990512

36. De Regil-González P, Santiago-Galindo PZ, Nava-Bringas TI. Postural alterations of the spine associated with the use of heels. An Med Asoc Med Hosp ABC. 2020;65(1):35-40. DOI: 10.35366/92916

37. Silva AM, de Siqueira GR, da Silva GA. Implications of high-heeled shoes on body posture of adolescents. Rev Paul Pediatr. 2013 Jun;31(2):265-71. [PubMed] DOI: 10.1590/s0103-05822013000200020

38. Weitkunat T, Buck FM, Jentzsch T, Simmen HP, Werner CM, Osterhoff G. Influence of high-heeled shoes on the sagittal balance of the spine and the whole body. Eur Spine J. 2016 Nov;25(11):3658-3665. [PubMed] DOI: 10.1007/s00586-016-4621-2

