Assessment of the High-Heel Shoes Effect on Head Protrusion Angle

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ABSTRACT

Purpose: Wearing high-heel shoes has become a habit among women of the present era. Statistics show that around 60% of women wear high-heel shoes at least thrice a week. High-heel shoes cause postural changes and damage body joints. The present study was conducted to assess the effect of high-heel shoes on the head protrusion angle.

Methods: This study was conducted at University of Social Welfare and Rehabilitation Sciences, Tehran, Iran. A simulated instrument to high-heel shoes was used in this research. Participants of this study were 25 healthy female students with the average (SD) age of 26.64 (3.86) y, average (SD) weight of 57.04 (7.06) kg, average (SD) height of 164.04 (5.76) cm, and average (SD) body mass index of 21.17 (2.14) kg/m^2. A digital camera was used and fixed on a 1-m tripod at the distance of 2.40 m from the used instrument on the heel. A software (Corel VideoStudio ProX4) was used to get the pictures from the movie for each cm increase in heel height and 9 pictures were taken from 0 to 8 height points. AutoCAD 2012-English software was used to take measurements at 9 levels.

Results: The obtained data and the correlation between variables were analyzed by using ANOVA. Statistical analysis showed a significant reduction in the head protrusion angle. Results also showed significant relationship ($P<0.05$) between heel height and study variables.

Conclusion: The present study showed the relationship between reduction in head protrusion angle and increase in heel height.

1. Introduction

Wearing high-heel shoes has become a habit among women of the present era [1]. Statistics show that around 60% of women wear high-heel shoes at least thrice a week [2]. Increase in heel height affects the body mass and changes the center of gravity which ultimately brings the compensatory postural changes, including the change in knee alignment [3]. Aesthetic features of high-heel shoes are the main reason of their popularity among women. High-heel shoes make the women and their legs and thighs look taller. The soles also look smaller after wearing

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high-heel shoes. Once a famous fashion designer was asked about the reason for shoes inconvenience. He replied that I look at the shoes as a work of art and comfort gets the least importance in the shoe design [2].

High-heel shoes are of different kinds and could be categorized into 5 types based on their width and height. These shoes affect the body by different mechanisms. Proper coordination and accurate adjustment between the muscles, tendons, and bones of the upper limb, pelvic and spine are necessary for the healthy movement [4]. Such coordination and accurate adjustment happen slowly and may cause problem after disturbing the balance [5]. Use of high-heel shoes is the main factor which disturbs the balance and causes the joint injuries after postural change [6]. In normal stance, least pressure should be put on the joint to maintain suitable posture. Any factor which can deviate the normal posture disturbs the balanced musculoskeletal system and causes the joint injury. Other than high-heel shoes, different factors such as muscular imbalance, bad occupational posture, pregnancy, over weight, old age, incorrect movement pattern and psychological problems, and so on could result in unnatural and unwanted body posture [7].

Wearing high-heel shoes for long duration affects the joints and changes posture. Thus, postural assessment by physiotherapists is very important in such conditions [8]. After the change in line of gravity and increase of torque arm, more weight is exerted on the joint surface which damages the joint [6]. Postural disorder due to high-heel shoes not only causes musculoskeletal problems [9] but also affects the occupational health and activity of daily life. Therefore, high-heel shoes effect on joint biomechanics, posture, and gravity line is a much needed research topic to decrease many postural disorders. Unfortunately, previous studies had shown contradictory results in standing position with the increase in heel height. Different changes in the angle of forward head has also been reported which is also debatable. Several previous studies have also reported increase, decrease, and no change in the angle of head position, but only few studies discussed the postural change due to high-heel shoes. Tools and devices used in the previous studies were different which might be the reason for different results.

This topic became more important when we found the high prevalence of neck pain among females who wear high-heel shoes. Natural curves in the spine and pelvis play an important role in the static and dynamic body position and decrease extra load over body while standing. In normal vertebral column, the line of gravity passes through the concave side of each vertebral arch. Therefore, in an intended posture, the gravity line causes the creation of torque in the direction of maintained intended position in each vertebral arch. Increase in the heel height is a factor, which changes the spatial relation between gravity line and vertebral arches. Any abnormal change in the degree of spinal curves results in the initial compensatory changes in the trunk, pelvis, and lower limb to maintain gravity line at supporting surface. Thus, the increase in the height of high-heel shoes on posture is harmful for the normal function of musculoskeletal system. Keeping in mind the above discussed problems and frequency of visits made to the physiotherapy clinics by females who wear high-heel shoes, research with regard to changes in angle after forward head posture is necessary to have proper treatment. The present study was conducted to assess the changes in the angle of head protrusion after increase in heel height during standing.

2. Materials and Methods

The sample size was calculated by using the following formula [10]:

$$N=\frac{(z1\text{-}\alpha+z1\text{-}\beta)^2}{z.^2}+3$$

$$z.=1/2\text{Ln}\,\frac{1+p.}{1\text{-}p.}$$

By assuming α value as 0.05 and β value as 0.15, 25 female students with the average age of 26.64 (SD=3.86) y, average weight of 57.04 (SD=7.06) kg, average height of 164.04 cm (SD=5.76) and average body mass index of 21.17 kg/m^2 (SD=2.14) were recruited by convenience sampling method from Tehran, Iran. All female students voluntarily took part in the study. Samples were selected based on inclusion and exclusion criteria. All healthy individuals without any previous fracture, surgery in spine and lower limb were included in the study. Other inclusion criteria were absence of balance problems, musculoskeletal disorders such as rheumatoid arthritis, neurological problems (dementia, Parkinsonism), vestibular disorders, unsolved visual problems, psychological issues.

They should not use sedative and balance disturbing drugs. All the individuals having any neurological or structural problem and unable to stand with high-heel shoes were excluded from the study, too. Information regarding inclusive and exclusive criteria was collected by the researcher through questionnaire and interview. All participants signed the consent form before taking part in the research. Demographic information of all participants was collected using questionnaires.

A device with an aluminum frame of 25 to 35 mm thickness was used to simulate heels. The individual stood on the moving surface of the device and the heel height was increased keeping the sole stable on the surface by using jack alligator and control system connected with electricity. A caliper calibrated for 0 to 8 cm was placed along the moving plate of the device to show the increase in heel height. This device increased the height similar to the high-heel shoes. It also had the capacity to continuously and steadily raise the height form 0 to 8 cm. Increase in height could be steady or interrupted to assess the compensatory changes in both conditions. The device could be adjusted according to the sole size as the movable plate was mounted inside the rails. Structural dimensions of the device were as follows; length 97 cm, width 57 cm, height from ground surface 16 cm (Figure 1 and 2). By considering the maximum weight as 130 kg, a direct current electrical motor was supplied with 15 Amp and 12 V. The participant stood on the device in such a way that her heels were on the moving surface and the anterior part of the soles were on the stable surface.

After increasing the heel height (with the help of device), the joint changes were easily measureable. Device increased the heel height with the speed of 3 mm/s. For safety purpose, stepping surface was also considered with the dimension of (57×57 cm) and changeable angle of the moveable surface was from 0 to 50 degree. After collecting the demographic data, the height and weight of the individuals were measured by using measuring tape and weighing balance. Occipital ridge and tragus of the ear was also marked. Plastic labels of white colors with 1 mm diameter were used and fixed by pink color tape.

A digital camera (8 Mp, resolution 2448*3264, sensor 1.3, Pixel size of 1.5 µm) was used with the lens of 29 mm focal length. Camera was fixed on a 1-m height tripod at the distance of 2.40 m from the used instrument on heel. The participants stood by placing the heels on the device at a distance of 15 cm from plumb line. Faces of the participants were covered with veil. After switching on the button, the device attains the heel height of 8 cm and a person made video of the entire procedure from the sagittal view simultaneously. When the heel height reached at 8 cm, the person got down.

A software (Corel Video Studio Pro X4) was used to get pictures from the movie for each cm increase in heel height and 9 pictures were taken from 0 to 8 height points. AutoCAD 2012-English Software was used to take measurements at 9 levels. Protrusion of the head or CV angle is the angle made by a line intersecting the horizontal line through the spinous process of C7 in such a way that it connects the tragus of the ear with the tip of spinous process of C7. The smaller the CV angle, the higher the quantity of head protrusion.

Assessment of reliability

To check reliability, the test was repeated after 10 days by taking measurements with the AutoCAD software and average values of these two tests were reported. The position adopted by the participants was re-assessed by repeating the test procedure on a group of 5 individuals after 3 hours. All the measurements for test-retest procedures were performed by an expert. Relative reliability was assessed by using Intraclass Correlation Coefficient (ICC) [12].

3. Results

Reliability results showed that ICC was satisfactory. Table 1 presents the reliability of head protrusion measurements with 95% Confidence Interval (CI).

Data analysis

All collected information was analyzed by SPSS (Version 23). Statistical significance of the test was consid-

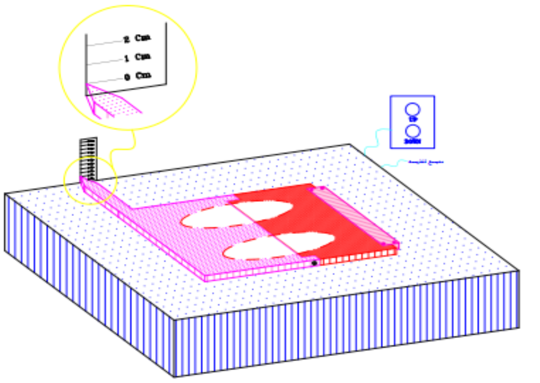

Figure 1. Anterior view of the device.

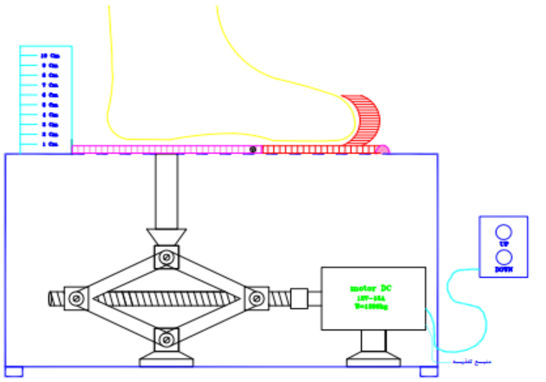

Figure 2. Lateral view of the device on the horizontal surface (Heel at 0 cm).

Table 1. Intraclass correlation coefficient.

	Intraclass Correlation	95% Confidence Interval		F Test With Value 0			
		Lower Bound	Upper Bound	Value	df 1	df 2	Sig.
Single measures	0.932[a]	0.820	0.991	247.480	4	68	0.000
Average measures	0.996[c]	0.988	1.000	247.480	4	67	0.000

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ered if P<0.05. Tables were drawn by using Excel 2016. Theoretical normal distribution of the variables was assessed by Kolmogorov-Smirnov test. Significant value with more than 0.05 (P>0.05) was considered for normally distributed variable. Height, weight, body mass index, and head protrusion angle had the normal distribution but age did not. Descriptive variables were consisted of age, height, weight, and BMI which are shown in Table 2.

To assess the changes in the measured variables, repeated measures ANOVA was used [10]. According to the hypothesis (H_0), any change in the shoes heel height did not show significant change in head protrusion. Hypothesis H_0 was rejected (P=0.0001). It also shows significant difference in head protrusion angle at different heel height positions. With the increase in heel height, the angle of forward head protrusion showed significant changes. Head protrusion angles were measured at different heel heights by Bonferroni method. All the measurements of the curves and angles were performed in a precise manner. Results obtained in the present study may have an effective contribution in the clinical assessment to prevent the problem and better treat the patients.

4. Discussion

No doubt this change was related to the change in gravity line after increase in heel height of the device. Previous studies had shown contradictory results with the present study because of few reasons. Some previous studies had not explained the specific duration for which the high-heel shoes had been used. Participants of the present study were only females but previous studies had performed similar studies on males and females. The present study was performed on females and the sample used for high-heel shoes for this research was selected from the society.

It is quite possible that postural changes after heel height affects the musculoskeletal system and motor function. After the increase in heel height, the natural body posture changes due to compensatory changes which ultimately causes the pain and musculoskeletal injuries in spine and joints of lower limb. A number of studies had been done in this area but there were still many contradictions regarding the postural changes after increase in heel height. Therefore, the present study aimed to assess the change in head protrusion angle after increase in heel height.

The obtained results showed significant reduction in head protrusion angle of 4 cm heel height. In other words, at least 4 cm increase in heel height is required to change the head position. Heel height causes the center of gravity to move forward. After the changes in line of the gravity, the body adopts forward head posture and in case of repetitive use, the individual may experience headache and other neuromuscular disorders. According to the obtained results in a short duration, it was a compensatory change because of the changes in gravity line toward forward direction and it should be noted that

Table 2. Measures of central tendency and dispersion variables in 25 participants.

Variable	Domain	Min	Max	Mean	SD	Variance
Age, y	14	21	35	26.64	3.86092	14.907
Height, cm	25	150	175	164.04	5.76975	33.29
Weight, kg	30	42	72	57.04	7.06211	49.873
BMI, kg/m^2	7.07	17.85	24.91	21.1701	2.14455	4.599
Forward head protrusion, degree	5.5	48.5	54	51.1311	1.54166	2.377

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whether these changes could remain after prolong use of high-heel shoes or other compensatory changes may occur according to the new position of gravity line.

Alexander in his theory introduced the head and neck control as the true control of posture; he also mentioned that the key to a good posture lies in the head and neck. The present study has also reported the reduction in head protrusion angle with the increase in heel height. In 1998, Opila KA et al. conducted an experiment to know the effect of high-heel shoes on postural line [13]. They studied on 19 individuals with high-heel shoes and without high-heel shoes. By using the anatomical landmarks, they assessed the change in gravity line and realized that people who wear high-heel shoes, face the problems like posterior pelvic tilt, reduction in the distance between knee and ankle joint from gravity line, posterior displacement of the head, posterior dislocation of the vertebra and straightening in the lumbar spine.

There was not a reasonable change in the greater trochanter. Prolong use of high-heel shoes increases lordosis due to change in the muscle tone which is contrary to the results obtained from the present study. Opila reported compensatory posterior displacement of the head and shoulder which was also not consistent with the results of present study. In other words, anterior transfer of the gravity line was not till that extent where compensatory changes would have been taken place. The present study showed a significant negative correlation between the heel height and head protrusion angle ($r=-0.306$, $P<0.0001$). Results of the present study represent the condition of a specific population and the study was performed with limited resources under certain conditions. Therefore, more such studies are needed in this topic.

Reduction in head protrusion angle was observed with the increase in heel height. Physiotherapists and other health care professions should pay full attention on the effects of high-heel shoes after change in head protrusion angle [14]. Also, it is the core duty of all physiotherapists to provide better awareness regarding correct posture.

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Conflict of Interest

The authors declared no conflict of interests.

References

[1] Silva AM, Siqueira GR, Da Silva GA. Implications of high-heeled shoes on body posture of adolescents. Paulista Journal of Pediatrics. 2013; 31(2):265-71. PMID: 23828066

[2] Kisner C, Colby LA. Therapeutic exercise: Foundations and techniques. 5th ed. Philadelphia: FA Davis; 2007.

[3] Kendall FP, MCcreary EK, Provance PG. Muscles, testing and function. Baltimore: Williams & wilkins; 1993.

[4] Nordin M, Frankel VH. Basic biomechanics of the musculoskeletal system. Baltimore: Williams & wilkins; 2001.

[5] Hamilton N, Luttgens K. Kinesiology Scientific Basic of Human Motion. NewYork: Brown & Benchmark; 2002.

[6] Levangie PK, Norkin C. Joint structure and function: A Comprehensive Analysis. Phladelphia: FA Davis; 1990.

[7] twomey LT, Talore JR. Physical therapy of the low back. New York: Churchill Living Stone; 1994.

[8] Gould JA. Orthopaedic and sports physical therapy. Missouri: Mosby; 1990.

[9] Basmajian JV, Deluca CJ. Muscle alive their function revealed by electromyography. Baltimor: Williams & wilkins; 1985.

[10] Dixon WJ, Massey FJ. Introduction to statistical analysis. New York: McGraw-Hill; 1969.

[11] Domholdt E. Physical therapy Research: Principles and applications. Philadelphia: WB Sawnders company; 1993.

[12] Carmines EG, Zeller RA. Reliability and validity assessment. California: Sage publications; 1979.

[13] Opila KA, Wagner SS, Schiowitz S, Chen J. Postural alignment in barefoot and high-heeled stance. Spine. 1988; 13(5):542-7. doi: 10.1097/00007632-198805000-00018

[14] Licht SH, Basmajian J. Terapeutic exercise. Baltimor: Williams & Wilkins; 1965.