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Effect of High Heels on Lumbar Lordosis, Range of Motion and Muscle Endurance in College Going Females

KEYWORDS: High heels, Muscle endurance, Lumbar lordosis, ROM

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ABSTRACT *Wearing high heels is stressful on joints of the foot as whole of the body weight rests there. The purpose of the study was to see the effect of high heels on lumbar lordosis, ROM & endurance in college going females. A convenient sample of 60 healthy females in age group of 18-26 years fulfilling the inclusion criterion was taken from GJUS&T, Hisar. They were further divided into two groups, group A consisted of 30 females wearing high heels of more than 2 inches and group B wearing heels with heel height less than 2 inches. The values of lumbar lordosis, ROM and endurance of lumbar flexors and extensors were measured for each subject. Unrelated t-test was used to compare the differences between the groups. The results showed that females wearing high heels were found to have increased lumbar lordosis and decreased endurance of lumbar flexors than those wearing heels with less height. These findings could be an indicator for the development of back pain and other musculoskeletal problems in females wearing high heels than those not wearing heels or wearing heels with less height on regular basis.*

BACKGROUND

Media and advertising depicts heels as a symbol of power, success, sex appeal and femininity. Wearing high heels not only improves a women's height and confidence but also her posture and attitude. Wearing high heels convey the impression that a woman cares about her appearance. High heels are preferred by all women to enhance charm, beauty and draw attention from the society. 37% to 69% of women wear high heels day-to-day, but they tolerate the discomfort in order to look taller, stylish and more professional (Esenyel et al, 2003 & Moraes et al, 2012).

Wearing high heels force a shift of balance, as the heel is put on the ground first and make a more elegant and powerful gait. As the heel height increases there is a significant decrease in gastrocnemius and an increase in tibialis anterior activity during walking. Therefore therapeutic use of heel lift is justified with tendoachilles bursitis, tenosynovitis of achilles tendon and post-operative management of ruptured achilles tendon (Lee et al, 1987). Earlier studies proves that high heels may predispose to degenerative changes in knee joint (Kerrigan et al., 1998) but recent research suggest that raised heels are sometimes associated with pain relief in some patients with osteoarthritis, the apparent positive effects of high heels could be related to gait changes that reduces knee loading (Nelson 2011).

High heels also have consequent negative side effects such as sprained ankle (Nieto and Nahigian, 1975), low back pain due to increased spinal curvature, leg pain due to added weight placed on toes (Jang & Kim, 1998; Yoe, 1994; Hyun & Kim, 1997), shortened achilles tendon (Scholl, 1931), decreased stride length (Adrian & Karpovitch, 1965; de Lateur et al., 1991), walking speed and mobility (Murray et al., 1970; Alexander, 1992). Wearing high heels is stressful especially on the joints of the foot because whole of the body weight lies there. Clinical research shows that height of a heel has a direct impact on lumbar spine as well as other parts of the body. (Lee et al., 2001).

Citing medical, postural & safety faults American Podiatric Medical Association views high heels as "biomechanically & orthopedically unsound". When wearing high heels during walking, the foot is held in a downward position, which keeps the knee, hip & low back in a somewhat flexed position and prevents the muscles that cross the backside of these joints to stretch out as they normally would. Overtime, this can lead to stiffness, pain and injury. High heels can also cause low back strain because the heel causes the body to pitch forward more than normal, putting excess pressure on the back (Dananberg & Trachtenberg, 2000). 75% of women using high heels had one or more deformities in the forefoot such as 71% hallux valgus, 50% hammer toes, 18% bunions of the metatarsal V, 13% prominence of the metatarsal head and 4% had multiple deformities (Frey et al., 2000). Many times women complain that wearing of high-heeled shoes causes them to have low back pain. Some doctors and therapists seem to think that the source of low back pain is high heeled shoe that causes an increase of the lordotic curve of the lumbar spine and this increased lumbar lordosis is the cause of pain.

Preliminary studies addressed the increase in lumbar lordosis with increase in heel height (Russell, 2010; De Oliveira Pezzan PA et al, 2011; Opila et al, 1988; Dananberg & Trachtenberg, 2000; Raymond Arias, 2005 & Smith, 1999) while other studies reported that lumbar lordosis decreased with raised heels (Russell, 2010; Coates et al, 2001 & Franklin, 1995). It has also been reported that there was no significant difference in the average lumbar curvature

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or pelvic tilt among users of different shoe heights. (Snow & Williams, 1994 and Russell, 2010) So the effect of high heels on lumbar lordosis conflicts with most of the published research.

Mika et al (2011f) reported higher bioelectrical activity of cervical paraspinal muscles during gait in high heel shoes in comparison to gait without shoes. There are various studies which states that there is increase in erector spinae muscle activity with high heels walking (Kim et al 2011 & Hashemirad et al 2009). Increased lumbar erector spinae muscle activity associated with wearing high heels could exacerbate muscle overuse and lead to low back problems (Mika et al 2012). Decreased trunk muscle endurance has been identified as one of the potential risk factor for the development of low back pain. (Cowley et al, 2009; Nourbakhsh et al, 2001 & Tsuji et al, 2001). But none of the study observed the effect of high heels on endurance of lumbar flexors & extensors.

In middle-aged women wearing high heels are associated with rigid lumbopelvic region and reduced pelvic range of motion. (Mika et al 2012). Coates et al (2001) demonstrated that the use of high heels, compared with barefoot condition causes reduction in lumbar flexion range of motion. But no study has been done on the long-term effect of high heels on lumbar range of motion.

So an effort has been made & the present study was designed with an aim to know the effect of high heels on lumbar lordosis, lumbar range of motion & endurance of lumbar flexor & extensor muscles in high heels users among college going females.

MATERIALS & METHODS

Subjects were recruited through advertisements placed on notice boards of departments and at girl's hostel of Guru Jambheshwar University of Science & Technology. A total of 60 healthy young females in age group of 18-26 years participated in the study. Using convenient sampling method the subjects were divided into 02 groups. As per the inclusion criteria females wearing footwear with heel height ≥ 2 inches for a period of more than 01 year with 4-5 days/week and 4-5 hrs/day were taken in group A and those wearing heels with height < 2 inches for a period of more than 01 year with 4-5 days/week and 4-5 hrs/day were taken in group B. Females having any pathology of hip, knee, recent history of fracture, having low back pain, use of block heels or platforms, having scoliosis greater than 15 degrees as determined by visual examination, have undergone any kind of previous back surgery, having pain medications and those having active lifestyle were excluded from the study. Written informed consent was obtained from all subjects.

Materials used

- Pen, Pencil
- Flexible ruler
- Drawing book for drawing the lumbar curve of the subject
- Inch tape for measuring lumbar flexion and extension range of motion
- Stop watch for measuring endurance of lumbar flexors & extensors muscle

Methods

Measurements were taken for various variables which include lumbar lordosis, lumbar flexion & extension ROM and endurance of lumbar flexors and extensors.

a. Measurement of lumbar lordosis

For measurement of lumbar lordosis flexible ruler method as used by F.Seidi et al (2009) in their research was used. The method has good intra rater reliability (ICC=0.92), inter rater reliability (ICC=0.82) and validity 0.91. The subjects were instructed to stand erect with their eyes directed horizontally and lower back exposed to measure lumbar lordosis, their arms at their sides and their feet placed on a set of paper footprints secured to the floor (with heels of the footprints at about 15 cm apart). Subject was fixed using two adjustable arms of stabilizer in sternum xiphoid process and pelvis superior surface for measuring lumbar lordosis. Two landmarks, spinous process of T12 as the beginning of curvature & spinous process of S2 as the end of curvature were used. The examiner while standing behind the subject & using Hoppenfeld (1976) method to find two bony landmarks, the bony landmarks was marked with removable colored adhesive dots. A flexible ruler was set along the lumbar lordosis region of the subject until it shaped lumbar lordosis curvature. After the ruler was fixed the points in contact with the middle parts of dots were marked with a color pen. The tester then carefully removed the flexible ruler so as not to distort the shape & without a change in the shape of the ruler it was carefully placed on a white paper. The outline of the curve was traced onto the paper, and the markings that corresponded to the T12 and S2 levels were labeled. For lumbar-lordosis angle calculation, points from T12 spot to S2 spot were connected by a straight line and the deepest part of the curve was marked (Rajabi et al, 2008). These lines were named as L & H respectively and lumbar lordosis was calculated by using the following equation:

$\theta = 4\text{Arc tan}2H/L$

Lumbar lordosis was measured twice for each subject with a time lag of one minute.

b. Measurement of lumbar range of motion

For measuring lumbar range of motion the Modified-Modified Schober Flexion/Extension technique used by R.Williams et al (1993) was followed. The tape measure marked in 1 mm increments was used to obtain measurements. To ensure that the length of the tape measure did not change with repeated use, the accuracy of the tape measure was checked by comparing the centimetre scale on the tape with a metal meter stick. All subjects were instructed to stand erect with their eyes directed horizontally, their arms at their sides, and their feet placed on a set of paper footprints that were secured to the floor (heels of the footprints were about 15 cm apart). ROM was measured with the subject in a standing position with exposed lower back from the gluteal fold to the mid-thoracic spine. The examiner identified the PSISs by marking the inferior margins of the subject's PSISs. A mark was drawn along the midline of the lumbar spine horizontal to the PSISs. Another mark was made 15 cm perpendicularly above the original mark. The tape measure was then lined up between the skin markings. With the tape measure pressed firmly against the subject's skin and while holding the tape measure with fingertips, for lumbar flexion range of motion, the therapist instructed the subject to bend forward. When the subject bent forward into full lumbar flexion, the new distance between the superior and inferior skin markings was measured to the nearest 01mm. The change in the difference between the marks was used to indicate the amount of lumbar flexion. For lumbar extension range of motion, the same landmarks and procedures described for the flexion technique were used for measuring lumbar ex-

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tension. The therapist lined up the tape measure between the markings. While holding the tape measure, firmly against the subject's skin, the subjects were instructed to place the palms of the hands on the buttocks and to bend backward into full lumbar extension. The new distance between the superior and inferior markings was measured to the nearest 1mm. The change in the difference between the marks was used to indicate the amount of lumbar extension.

c. Measurement of lumbar flexor & extensor endurance

The endurance of the lumbar flexor muscles was measured with curl up test. Before the main test, the test was demonstrated by the physical therapist. In particular, the subject was lying in supine with the knees at an angle of 90^0 and with arms straight pointing towards their knees. Straps were used to secure their feet on the plinth. The subject was then instructed to curl up until their iliac crests were raised from the table and was instructed to hold this posture for a maximum of 240 seconds. During the test therapist visually checked the maintenance of performance. The test was terminated when the subject could not maintain the position. Therapist recorded time for further analyses. Verbal instructions to the subjects for correct positioning were provided only at the start of the test. (Kofotolis & Kellis, 2006)

The endurance of lumbar extensor muscles was measured by use of modified Sorensen extension test. Before the main test the position was demonstrated by the physical therapist to the subjects. The subject laid face down half way on plinth with iliac crest positioned at the edge of the plinth. Stabilization was given by physical therapist over buttocks and mid-thigh of the subjects. The participants were asked to maintain a horizontal position for as long as possible for a maximum of 240 seconds with no rotation or lateral bending. The test was terminated when the subject's upper torso dropped below the horizontal and time was recorded for analysis. (Kofotolis & Kellis, 2006)

DATA ANALYSIS

The data of 60 healthy young females was analyzed using SPSS version 17, mean and SD of each variable was calculated for both the groups. Group A & B having 30 subjects each were compared by using unrelated t test for variables and was seen whether height of the heel produced any significant effect on ranges of lumbar flexion & extension, lumbar lordosis and endurance of lumbar flexors and extensors.

RESULTS

The mean age of subjects in group A & B was 22.13 & 21.13 years respectively. Table 1 shows comparison of lumbar lordosis, endurance of lumbar flexors & extensors and ROM of lumbar flexion & extension in group with high heels (Group A) and without high heels (Group B).

Table 1: Comparison of Lumbar lordosis, Endurance & ROM in Group A & B

Variables ↓	Groups →	A (High Heels)	B (Without High Heels)	t- value	P value
Lumbar lordosis (degree)		72.27±14.046	60.50±14.415	3.205*	P≤0.001
Endurance (Secs)	Flexors	23.64±13.143	39.49±20.672	-3.543*	P≤0.001
	Extensors	31.37±14.551	34.44±18.47	-0.716^{NS}	
Range of Motion (cms)	Flexion	6.08±1.053	6.09±1.048	-0.032^{NS}	
	Extension	2.32±0.719	2.36±0.847	-0.203^{NS}	

*S= Significant, NS=Non Significant

The mean lumbar lordosis for group with high heels (72.279± 14.046 degrees) is greater than group without high heels (60.501± 14.415 degrees). The result of unrelated t test shows that there is statistically significant difference in lumbar lordosis between group with high heels and without high heels. (t= 3.205, p≤0.001).

The mean values of lumbar flexors endurance in group A and B is 23.642±13.143 and 39.49±20.672 seconds respectively, endurance being more in group B (without high heals). The result of unrelated t test shows that there is statistically significant difference in lumbar flexors endurance in group A & B (t= -3.543, p≤0.001).

The mean of lumbar extensors endurance in group A & B is 31.37±14.551 and 34.443±18.47 seconds respectively. The result of unrelated t test show statistically nonsignificant differences in lumbar extensors endurance of group A and B.

The mean values of lumbar flexion ROM in group A & B is 6.088±1.053 and 6.096±1.048 cms respectively and the mean values of lumbar extension ROM in group A & B is 2.321±0.719 & 2.362±0.847 cms respectively. The result of unrelated t test show statistically nonsignificant differences in lumbar flexion & lumbar extension ROM between group A and B.

DISCUSSION

Wearing high heels is stressful especially on the joints of the foot as whole of the body weight lies there. Clinical research shows that height of a heel has a direct impact on the lumbar spine as well as other parts of the body (Lee et al., 2001). The result of the present study indicates that there is increase in lumbar lordosis & decrease in lumbar flexion endurance in high heels users as compared to non-high heels users.

Increase in lumbar lordosis is observed in high heels users as compared to non-high heels users. This finding is consistent with the findings of few of previous studies. Lee et al (2001) concluded that as heel height increases, high heels creates a more unstable posture and compressive forces in the lumbar spine because of increase in the height of the centre of mass of the body and thus increase in the lumbar lordosis. High heels alters the pelvic inclination and changes in postural muscle tone due to the altered pelvic inclination may, in the long term, result in hyper lordosis of the lumbar spine (Cowley et al 2009). However, there are a few studies which report contradictory results. Manishtha et al (2010) showed that as the height of heel increases the extensibility of the muscles reduces but there is no effect on lumbar lordosis significantly. The findings of the current study are also inconsistent with findings of study done by Oplia et al. (1988). They observed the posture of subjects with barefoot and high-

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heeled stance and concluded that the wearing of high heels caused lumbar flattening, a backward tilting pelvis, a reduction of the distance of the knee and ankle from the line of gravity, and a posterior displacement of the head and thoracic spine.

A decrease in endurance of lumbar flexors in high heels users as compared to non-high heels users was also seen in the present study. There is increase in erector spinae muscle activity and increase in abdominal muscle length, during high heel walking (Kim et al, 2011 & Hashemirad et al, 2009). When muscle length increases or decreases beyond its resting length, muscle force production decreases in a bell shaped form (Paula et al**)**. This relationship is seen in high heel users also and is the reason of decrease in endurance.

The limitation of the study was small sample size and only college going females were considered in the study. Future studies could also be done for females of different age groups wearing high heels.

Clinical implication- High heels have been found to be associated with decrease in lumbar flexor endurance and increase in lumbar lordosis. Use of high heels might not seem to be a problem for short term use but long term use of high heels could lead to problem, like low back ache. Evidence suggests that increase in lumbar lordosis, decrease in lumbar muscle endurance are major contributors for low back pain which may be prevented by use of low height heels or strengthening of abdominal muscles. It is recommended to limit the use of high heels for less than four hours. Also it should not be used on frequent basis, no more than three times a week.

CONCLUSION

The present study concludes that high heels users have increased lumbar lordosis, decreased lumbar flexor endurance as compared to non-high heel users among college going females. These findings clearly indicate the downside of wearing high heels on regular basis & the chances of having musculoskeletal problems.

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