**Influence of adjusting the thoracic and lumbar curvature on the displacement of the center of mass in women**

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ABSTRACT

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| **Aims:** The present study aims to quantify the influence of adjusting the thoracic and lumbar curvature on the displacement of the center of mass in women with different heel-to-floor heights.  **Methodology:** To carry out this study, 15 university students (mean age 23.3 ±3.8 years) from Unicentro (University of Middle-West, Guarapuava, Parana, Brazil) participated in the research. Using the photometry method, the women's thoracic and lumbar angles were analyzed with demarcations at the aforementioned angles and the height of heels was simulated using a platform. The positioning of the center of mass was measured using the Dawson method. Those evaluated were divided into two groups, those who felt pain and those who did not feel pain in the lumbar spine.  **Results:** Theresults showed no significant difference for the angulations in relation to the increase of the heel with the floor. Thus, the displacement of the center of mass with the increase in height from the heel to the ground was positioned further forward. however it did not show a significant difference.  **Conclusion:** Therefore, it can be concluded that the modification of the thoracic and lumbar angles and the anterior displacement of the center of mass were no longer evident in women with low back pain. |

*Keywords: Lower back pain, balance and posture disorders.*

1. INTRODUCTION

The fashion dictated by designers highlights the use of high heels as a feminine aesthetic standard. Women, when admitting this pattern, use this type of footwear both in their daily lives and in refined places. One of the historical examples of hierarchy indicated by the use of heels is found in a 1917 report, published in the magazine The Lancet (1992).According to which, in the American army soldiers with higher ranks wore boots with higher heels than the others.

The footwear industry, in addition to aesthetic concerns. also recognizes the importance of comfort factors and footwear functionality, including with regard to the heel. In footwear biomechanics studies are focused on the interaction of shoes with the feet and the external environment. The results of these studies, for example, are the finding that wearing high heels increases support in the forefoot region (corresponding to the metatarsal bones) and provides a consequent relief from pressure in the rearfoot region (corresponding to the tarsal bones), and also that the plantar flexed position assumed by the feet in high-heeled shoes generates tension in the lower limbs (Kannan, et al., 2019).

In recent years, work-related musculoskeletal disorders (WMSDs) and workplace accidents have worried company managers and employees, mainly because of absenteeism, decreased productivity and decreased income. Professionals affected by these problems need to remain away from their work activities for a certain period. Disorders are problems that can occur when a person uses a certain part of the body too much, repeating or mobilizing gestures, which causes local pain in the joints (Monteiro, 1999).

The study by Opila et al. (1988), estimated the rectification of lumbar lordosis from markers at T12, L3 and L5. In this study, the measurement was performed in a static posture and over a short period of time, and the authors themselves admitted to problems in the measurement. Similarly, De Lateur et al. (1991), in an experiment carried out with eight women in a static posture, using rods fixed with adhesives at T12 and S2, inferred about the adaptations of the anatomical curvature in the lumbar region without finding significant results. Snow and Willians(1994) carried out a study with eleven women during a static posture under the influence of three different heel heights (19.1, 38.1 and 76.2 mm) and calculated the average angle of the lumbar curvature from markers on the skin at L1 and S2. To calculate the lumbar angle, they used a flexible ruler that reproduced the curve between L1 and S2. In this study, they also did not find a significant difference in the lumbar lordosis angle depending on the height of the heels. Bendix et al. (19984), calculated the average lumbar angle formed from two rigid segments drawn between markers on the spinous processes of T6, L4 and the midpoint of the sacrum bone. The present study aims to quantify the influence of adjusting the thoracic and lumbar curvature on the displacement of the center of mass in women with different heel-to-floor heights.

2. material and methods

This research presents a cross-sectional correlational study design. in which the sample was evaluated at just one moment in time and the results were analyzed using statistical tests that relate the variables.

The sample studied was 15 university women (mean age 23.3 ± 3.8 years) who study on the CEDETEG campus of the Unicentro (University of Middle-West, Guarapuava, Parana, Brazil), selected by convenience. As an inclusion criterion, participants should be women and students of the Physical Education course at Unicentro's CEDETEG Campus and as an exclusion criterion, the participant should have some health disorder that prevents the research from being carried out. The selected academics signed the TCLE, thereby giving their consent to carry out the research. Anthropometric data on body mass (kg) and height (cm) were collected to obtain BMI (body mass index in (kg/m2). To assess the prevalence of spinal pain a standardized questionnaire Corlett and Manenica (1980).

The assessment of the thoracic and lumbar angles was carried out using the photometry method, in which photographs were taken of the students' right sagittal plane with the demarcation of the aforementioned angles. The thoracic angle was assessed by the intersection of straight lines parallel to the spinous process of the seventh cervical vertebra and twelfth thoracic vertebra and the lumbar angle by the intersection of straight lines parallel to the spinous process of the twelfth thoracic vertebral and fifth lumbar vertebra, conform Christie et al., (1995). The photos were analyzed in Paint and Excel software, using the trigonometric method, which quantified the lumbar and thoracic angle.

To simulate the heel height of shoes, a device was used that raises the height of the person's heel in relation to the floor. thus representing the use of heels. Data was collected from various jump heights from the ground up to around 10 cm.

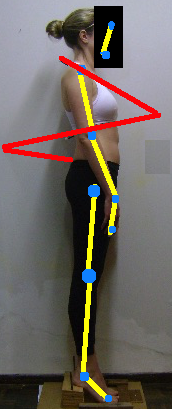


Figure 1. Biomechanical model of body.

The quantification of the displacement of the center of mass was also made using photometry with measurement using the segmental trigonometric method, conform the Dawson Method in Graça (2012). Thus, evaluating the change in the positioning of the center of mass of the human body in relation to the elevation of the heel height.

Data analysis was performed using descriptive statistics with mean and standard deviation. For inferential analysis, the repeated measures Anova test was used. All analyses were performed using SPSS version 20 software, with a significance level of p<0.05.

3. results and discussion

In this study, there was no significant difference in relation to lumbar and thoracic angulation, with increasing platform height, between women with and without pain. The results that stand out are observed in the displacement of the center of mass, which increases as the height of the platform increases.

Table 1- Comparison of thoracic angle. lumbar angle and displacement of the center of mass between women with and without low back pain.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Thoracic  angle (o)\* | | Lumbar  angle (o)\* | | Displacement of the center of mass (un)\* | |
| Mean | Standard  Deviation | Mean | Standard  Deviation | Mean | Standard  Deviation |
| With pain (4) | Height 0 (cm) | 42.3 | 11.2 | 32.8 | 14.4 | 31.0 | 10.0 |
| Height 2 (cm) | 40.0 | 8.0 | 30.2 | 10.5 | 33.4 | 11.0 |
| Height 4 (cm) | 37.1 | 12.2 | 29.4 | 12.1 | 37.3 | 9.8 |
| Height 6 (cm) | 38.4 | 12.7 | 30.0 | 9.2 | 36.5 | 12.9 |
| Height 8 (cm) | 39.5 | 14.0 | 28.1 | 10.1 | 37.7 | 8.6 |
| Height 10 (cm) | 40.3 | 12.6 | 28.0 | 7.5 | 38.4 | 11.7 |
| Without pain (11) | Height 0 (cm) | 40.5 | 10.7 | 34.8 | 10.9 | 30.9 | 13.3 |
| Height 2 (cm) | 40.4 | 11.6 | 35.5 | 12.2 | 36.7 | 13.4 |
| Height 4 (cm) | 41.0 | 9.7 | 35.4 | 12.3 | 36.2 | 14.9 |
| Height 6 (cm) | 43.3 | 12.6 | 37.3 | 12.6 | 38.7 | 12.5 |
| Height 8 (cm) | 41.2 | 10.2 | 36.5 | 12.5 | 43.2 | 13.9 |
| Height 10 (cm) | 43.6 | 9.2 | 36.4 | 12.6 | 39.7 | 14.8 |

\*Tested by repeated measures ANOVA, with a significance level of p<0.05. None of the variables showed a significant difference.

In a study carried out with Olympic wrestling athletes, significant results were obtained relating low back pain to an increase in the lumbar angle. The thoracic angle was also shown to be increased for athletes diagnosed with pain (Dezan et al., 2004). For individuals with postural changes, the results were similar, increasing the lumbar angulation from 19.3º (without pain) to 26.4º (chronic pain). The thoracic angle increased from 39.6º to 47.4º in individuals without pain and with pain respectively (Christie et al., 1995). Both women with pain and without pain presented approximate angulations in the thoracic and lumbar angle, which were not observable their increase for those who felt pain.

Regarding the analysis of the center of mass, it is not possible to make a comparison with other studies as a search in the literature does not reveal any similar assessment. However, a relationship can be established between the increase in height from the heel to the floor and the anterior positioning in the center of mass for both women with pain and women without pain. It is worth noting that this anterior projection may make it difficult for women to balance, even more so when they wear high-heeled shoes.

Ogunboyoet et al. (2019), in your study, showed that a point prevalence of low back pain is 7.1% and a-year prevalence is 53.5% among the lecturers. It affects female lecturers than their male counterparts. Low back pain was found to increase with age, work experience, prolong sitting and prolong standing. Often sitting for some minutes during played a protective role against low back pain. A risk as this is a pointer that lecturers are also exposed to occupational hazard since low back pain could contribute to early retirement.

Pegoretti et al., (2005), in their study aimed at verifying the adaptations that occur in lumbar lordosis under the influence of different heel heights during walking on a treadmill, it was observed that increasing the heel height of shoes caused a tendency to rectify lumbar lordosis when wearing high-heeled shoes during walking. The decreases in maximum and average lumbar curvatures were significant. The method used proved to be efficient and sensitive, allowing the quantification of the lumbar curve in movement, during walking, with more precision than traditional static methods. It is highlighted that the method of evaluating the behavior of the spine is similar to the present study.

4. Conclusion

With the results obtained in the analysis. it is not possible to make a relationship between the angles and the presence of pain due to the use of high heels. The similarity between data from women with and without pain is due to the small sample size. meaning it is not possible to make a significant average for angulations. To this end, research with a larger sample is suggested. The center of mass is shifted forward due to the increase in the platform, causing women to lose their balance. To remain balanced, the spine exerts greater force, which can trigger future pain in that region.

Authors’ Contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Ethical approval

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology.

Consent

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

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