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RELATIONSHIP BETWEEN PLANTAR ARCH INDEX AND POSTURAL BALANCE IN ADULT WOMEN WITH HIGH AND LOW FREQUENCY OF HEELED SHOES USE

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SUMMARY
The present study aims to analyze the relationship between plantar arch index and the postural balance in adult women with high and low frequency of use of heeled shoes. To obtain the plantar arch index (PAI) the printing plant method was used, with a plantar foot pressure. For postural balance data an AMTI force plate was used. The variables analyzed were: amplitude of anteroposterior displacement of the center of pressure (COPap), amplitude of medial-lateral displacement of the center of pressure (COPml) and average velocity of displacement of the center of pressure (COPvel). The results showed negative and strong correlations, according the criterion of Malina, in the low frequency of heels use group (LF) between two variables (COPap and COPml) and PAI (left) in the closed eyes closed condition, indicating that the less the plantar arch index of the plantar arch (cavus feet tend to) the greater the body sway of these young people. We conclude that individuals of LF group who have excessive increase of the medial longitudinal arch, in other words, minor PAI, have a increased postural sway.
Keywords: Balance, Cavus Feet, Heels Shoes.

INTRODUCTION
The human foot has three podal arches:, the lateral longitudinal arch, the anterior transverse arch and the medial longitudinal arch (MLA), which have the function of feet adaptation to ground irregularities [1].
The continuous use of high heeled shoes causes changes in the plantar arches, which may cause displacement of the center of gravity and result in imbalances in its users [2].
The measurement of plantar arch index, allows to found possible deformities in the MLA (planus or cavus feet), which can cause musculoskeletal misalignments, altering postural balance, and increasing the risk of falls. Based on these assumptions this study seeks to analyze the relationship between the plantar arch index and postural balance in adult women with high and low frequency of use of heels.

METHODS
The study group consisted of 18 female subjects divided into two groups: group of nine individuals in the low frequency of heels use group (LF) and nine individuals in theat high frequency of heels use group (HF).
The mean age, height and weight of the participants was were 44.83 ± 8.04 years, 1.59 ± 0.06 m and 58.12 ± 6.20 kg, respectively. The exclusion criteria of the study were: problems osteo-myo-articular (less for the longitudinal arch of foot), physical disability and / or mental, have hypertension, or diabetes, labyrinthitis, have pain in the spine or other problems that may interfere with results of balance. The study was approved by the local Ethics and Research Committee (CAAE - 08398612.8.0000.5346).

First we applied a questionnaire adapted from Manfio [3] was applied to determine the frequency of use of heeled shoes by the individuals individuals, and classify them in the groups of LF or HF.

The evaluation of the plantar arch index was accomplished by printing plant, using a plantar foot pressure. The footprints were scanned and transformed into digital images, as illustrated in Figure 1.

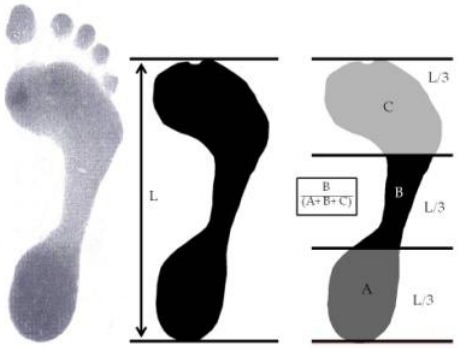

Figure 1: Method used for the classification of the plantar arch, according to Cavanagh and Rodgers [4].

The plantar arch index (PAI) was calculated dividing the footprint in three equidistant regions: rearfoot, midfoot and forefoot, excluding fingers. The index value is the ratio between the area of the midfoot and the total area of the footprint (B / (A + B + C)).
According Cavanagh and Rodgers, the ALM is classified in;

- ALM high or cavus foot (arch index ≤ 0.21)
- ALM normal or normal foot (0.21 < arch index < 0.26)
- ALM low or flat foot (arch index ≥ 0.26)

For data acquisition related to postural balance an AMTI model OR6-6 force plate was used. The raw data of forces

and moments from the force plate were filtered with a low pass 4th order Butterworth filter with cutoff frequency of 10 Hz. Then COP coordinates were calculated.

The variables evaluated were range of anteroposterior displacement of COP (COPap), range of medial-lateral displacement of COP (COPml) and average velocity of the COP (COPvel).

Two conditions were evaluated: opened eyes (OE) and closed eyes (CE) with arms along the body. The feet position was marked on a paper so that all trials were made at the same position. There were two trials with opened eyes and two with closed eyes. The sampling rate of the force plate was 100 Hz and the acquisition time was 30 seconds.

Data were submitted to descriptive statistics. Data normality was tested by Shapiro-Wilk's test. Pearson correlation test was used for parametric data and Spearman's for nonparametric to assess relationships between plantar arch index and variables of balance between groups. The significance level for all tests was 5% ($\alpha = 0.05$). For analysis the statistical package SPSS version 13.0 for Windows was used.

RESULTS AND DISCUSSION

In the LF group of 18 feet LF evaluated, 12 feet (66.6%) were classified as normal feet, seven (38.8%) in cavus and one (5.5%) in plan.

In the group of HF 18 feet evaluated, eight (44.4%) were classified as normal feet, 10 (55.5%) in cavus and no plan.

The results showed negative and strong correlations, according the criterion of Malina, in LF group between left PAI and COPap ($p = 0.04$), and between left PAI and COPml ($p = 0.03$), provided with eyes closed, indicating that the lower the plantar arch index (trend cavus foot) higher body sway. In the HF group differences were not statistically significant.

In this study the majority of women evaluated in the LF group showed normal feet and in the HF group cavus feet,agreeing with the results of Pezzan [7].

In this study the authors analyzed the influence of wearing high heels in the longitudinal plantar arch in adolescents by the footprint and characterization of foot type. It was found that the width of the plantar arch of the foot of users of high-heeled shoes was reduced when compared to another group. These findings show that high-heeled shoes changes the anthropometry of the foot with respect to the width of the plantar arch, suggesting a tendency to cavus foot.

Dorneles et al. [8] in a review on the use of high-heeled shoes, show that this type of shoe generates musculoskeletal overloads, including back pain, hallux valgus, calluses foot diseases, fractures and ligament injuries, and can change the anthropometry of the foot with respect to the width of the plantar arch, suggesting a tendency to cavus foot.

The statistically significant associations found in this study were only in closed eyes condition. It is observed that in the absence of visual information, other variables such as the PAI have greater importance in the body sway However, under normal conditions, the PAI has no effect in the postural balance in this study. Other authors [10,11] also found in their studies larger oscillations with closed eyes, suggesting a greater postural sway when compared with the opened eyes condition, or in addition to other sensory manipulation.

CONCLUSIONS

In the group with high frequency of use of high heels shoes, the greater the plantar arch index (tendency to cavus foot), greater the postural sway, in closed eyes condition. It is suggested to conduct further studies with a larger number of individuals and including the participation of different age groups.

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REFERENCES

1. Cashmere T, et al. Medial longitudinal arch of the foot: stationary versus walking measures. *Foot & Ankle* International, v. 20, p. 112-118, 1999.
2. Snow RE, et al. High heeled shoes: their effect on center of mass position, posture, three-dimensional kinematics, rearfoot motion and ground reaction forces. *Archives of Physical Medicine and Rehabilitation*, v.75, n.5, p.568-76, 1994.
3. MANFIO EF. Um estudo de parâmetros antropométricos do pé. 2001. 178f. Tese (Doutorado em Ciência do Movimento Humano) – Universidade Federal de Santa Maria, Santa Maria, 2001.
4. Cavanagh PR, et al. The arch index: an useful measure from footprints. *Journal of Biomechanics*, v. 20, p. 547-51, 1987.
5. Lin CH, et al. Development of a quantitative assessment system for correlation of footprint parameters to postural control in children. *Physiological Measurement*, v .27, n .2, p .119-30, 2006.
6. Lin CH, et al. Image analysis system for acquiring three-dimensional contour of foot arch during balanced standing. *Computer Methods and Programs in Biomedicine*, v. 75, p. 147-157, 2004.
7. Pezzan PAO, et al. Estudo do Arco Longitudinal Plantar de Adolescentes Usuárias de Calçados de saltos Altos. In: *CBB XII*, São Pedro, Brazil, 2007.
8. Dorneles PP, et al. Considerações biomecânicas sobre o uso do sapato de salto alto. *Lecturas: Educación Física y Deportes* - Revista Digital, v.14, n.139, 2009.
9. Jamet M, et al. Higher visual dependency increases balance control perturbation during cognitive task fulfilment in elderly people. *Neuroscience Letter*, v. 359, n. 1-2, p. 61-64, 2004.
10. Teixeira CS, et al. Avaliação da influência dos estímulos sensoriais envolvidos na manutenção do equilíbrio corporal em mulheres idosas. *Revista Brasileira de Geriatria e Gerontologia*, v. 14, n. 3, p. 453-460, 2011.