Plantar Weight Discharge Variation in Adulthood and Elderly: The Influence of Visual System and Physical Activity

Hadassa Costa Sousa¹, Martina Estevam Brom Vieira¹, Mariana Ferreira Moreira¹, Juliane Leite Orcino¹, Darlan Martins Ribeiro¹, Guilherme Augusto Santos Bueno², Thiago Vilela Lemos¹, Cibelle Kayene Martins Roberto Formiga¹ and Flávia Martins Gervásio¹

¹Universidade Estadual de Goiás (UEG), Goiânia - GO, Brazil
²Instituto Euro Americano de Educação e Tecnologia, Centro Universitário Unieuro, Brasília - DF, Brazil

*Corresponding author: Hadassa Costa Sousa, Universidade Estadual de Goiás (UEG), Goiânia - GO, Brazil

Abstract

Objectives: To analyze the variation of plantar pressure due to vision conditions and eyes open (EO) or eyes closed (EC) and its relationship to physical activity in women aged 50 and older.

Design: Transversal and analytical study, approved by the Research Ethics Committee of the Federal University of Goiás (n. 741,298/2014).

Setting: Developed at the Movement Laboratory of the Goiás State University (GSU), Goiânia, Brazil.

Participants: This study includes 150 women enrolled in the Open University of the Third Age (OUTA) of the GSU.

Measurements: The participants answered an anamnesis questionnaire in addition to the Mini-Mental State Examination (MMSE) and the International Physical Activity Questionnaire (IPAQ). Data about weight and pressure discharge areas were provided by Foot Work®, baropodometry software equipped with quartz sensors, capturing a frequency of 150 Hz.

Results: 142 women were elected to participate in the study. Vision influence on the distribution of their weight discharge was observed in the semitandem position with the right foot in front and semitandem position with the left foot forward. Foot type does not influence plantar pressure variation. The morphological foot type showed no relationship to age (p = 0.37 for the right foot and p = 0.93 for the left foot) or physical activity (p = 0.28 for the right foot and p = 0.96 for the left foot). The variation of the weight discharge plant also showed no significant relationship with age ($R^2 = 0.2$ and $p = 0.6$).

Conclusion: Variation in plantar pressure is not influenced by foot type in women aged 50 or older, as visual condition does not affect the variation in plantar pressure when compared to its effect on the morphology of the plantar arches. The level of physical activity showed no influence on plantar pressure variation.

Keywords

Weight-bearing, Aged, Women, Pressure, Foot, Postural balance

Introduction

The human foot ensures a base for support, which is essential to postural balance. Together with the skeletal, muscular, and ligamentous structures that make up the foot, the weight-bearing properties in static postures are an important proprioception return mechanism and play a major role in transferring and dampening forces throughout the foot during dynamic tasks [1].

The maintenance of this balance is what allows for a good performance of the dynamic activities of daily life and the practice of physical activities [2]. The way in which the body's weight is discharged into the base of support can be affected by several factors, classified into intrinsic factors such as physiological disturbances, anthropometric characteristics, and physical condition, or extrinsic factors such as gravity, erratic ground, and environment [3].

These factors can generate a state of imbalance, leading to a functional overload of the skeletal muscle system and causing sensory and nervous systems dys-
function. Changes in balance lead to the onset of pathological clinical problems, which are sometimes associated with diseases and deformities that affect the feet, such as pain, stress fractures, and calllosities [4,5]. The aging process brings changes to the features biomechanics, structure, and function of the foot and is associated with mobility impairment and falls [6].

The number of adult and elderly women is higher than that of men in the general population in Brazil [7] and it was demonstrated that they are at increased tripping risk and fall more frequently than age-matched men [8,9]. However, there is a deficit in the Brazilian and international literature on the identification of changes in static postural balance related to the quality of therapeutic exercise performance in women in the transitional age group between adulthood and elderly [9,10].

Although the study of plantar pressures has been extensively discussed in several papers, there are no sufficient studies in the current literature about the relationship between visual condition, age, physical activity, and the variation of plantar pressure in elderly women and for those who are in the transition age group between adult and elderly [1,11].

The proper biomechanical mechanisms of the foot are responsible for maintaining the distribution of plantar pressure. The most usual and reliable tools to study plantar pressure distribution are the force plate and baropodometric platforms [12,13]. The literature mentions a variety of protocols to be used in these tools. Among these is the Romberg Protocol, which is used for investigating the influence of visual feedback in the body sway control [14-16].

There are some indices in the literature that can be used to diagnose foot type, including the Staheli index. Various studies show footprint analysis methods for diagnosing foot type, using this clinical diagnosis as the gold standard, and their results show that these indices are suitable for this type of diagnosis in the adult population and have a high sensibility rate [17-19].

Baropodometry is an advanced pressure platform method used for mapping the pressure of the plantar surface and for the analysis of plantar pressure areas applied by the body in both static and dynamic tasks. It uses software to produce images similar to a podoscope, providing information about the distribution of loads during the standing position, peak pressure, and the detection of risk areas on feet, as well as stabilometric information [3,12].

The objective of this study is to analyze the variation of plantar pressure due to vision conditions with eyes open (EO) or eyes closed (EC) and its relationship to physical activity in women aged 50 and older.

Method

Study design

This controlled, non-randomized, transversal and analytical study was approved by the Research Ethics Committee of Goiás Federal University, decision number 3.646.405/2019. All participants provided written informed consent.

Sample

After data collection took place, the sample size was calculated, based on ANOVA, using G.Power 3.1.9.2 software, considering a 95% confidence interval, a power of 95% (type I error) for plantar pressure distribution with an effect size of 0.481, and a 0.05 significance level (type I error). The total sample required was 60.

All subjects were women enrolled in the Open University of the Third Age (OUTA) of Goiás State University (GSU). All of them were physically independent and at least 50-years-old. They had no history of lower limb, pelvis, or spine surgery and no medical diagnosis of rheumatoid arthritis or neuromuscular or neurodegenerative disease, including diabetes mellitus. They also had no visual impairment and partook in no alcoholic ingestion within 24 hours prior to data collection. All participants scored > 24 [20] and > 14 points considering the participants the educational level, with illiterate participants on the Mini-Mental State Examination (MMSE) [21].

Experimental setup

The participants answered an anamnesis questionnaire, with each of them reporting information such as their name, age, sex, disease, and/or surgery. To assess their cognitive state, the questionnaire used the MMSE [22], and to assess their physical ability, the International Physical Activity Questionnaire (IPAQ) was applied [23]. Data about weight and pressure discharge areas were provided by the baropodometry software Foot Work®, equipped with quartz sensors capturing a frequency of 150 Hz [24]. These data were used to balance the assessment and classification of morphological foot types.

Three postures were adopted for the plantar pressure analysis: The first in orthostatic feet in the normal base (side by side), the second in the semitandem position with the right foot in front, and the third in the semitandem position with the left foot in front. In each posture, the subject kept their eyes open for 60 seconds (EO) and then maintained the same position with their eyes closed (EC), giving a total of six condition evaluations for each woman according to the Romberg Protocol [15].

Procedures

The morphological structure of the foot was classi-
applied to analyze the relationship between age and plantar pressure, and the independent T-test was applied to analyze the relationship between plantar pressure and physical activity. The standard level of significance adopted was 0.01.

Results

During the study period, 150 women enrolled in OU-TA-GSU were eligible to participate in the study. From this number, eight were excluded for presenting inadequate data for their foot area to carry out the classification of their foot type. The average age was 67.96 (± 7.47), and the average body mass index (BMI) was 26.9 kg/m² (± 4.13), which classified them as overweight. They are irregularly active (2.73 ± 0.91) and have a good cognitive state (MEEM 27.06 ± 3.3).

Vision influence on the distribution of the weight discharge was observed regarding both situations, for the semitandem position with the right foot in front and semitandem position with the left foot forward. This influence was manifested throughout the sample group, regardless of whether the individual is physically active or sedentary (Table 1). Foot type does not influence this variable.

Participants who were classified with the normal foot type performed weight discharge in both lower limbs, with a predominance in the right lower limb and in the posterior region of the foot. This behavior holds for all other foot types. There is a predominance of pronation on both feet. There is no statistically significant difference in relation to the effects of vision (EO and EC) on foot pressure or in relation to the types of foot morphology considering the discharge variations (Table 2).

For the semitandem position with the right foot in front, there was a predominance of weight discharge in the left lower limb and in the posterior region of the foot with EO and EC. For the semitandem position with the left foot forward, there was a predominance of weight discharge in the right lower limb and in the posterior region of the foot with EO and EC.

The morphological foot type showed no relationship with age (p = 0.37 for the right foot and p = 0.93 for the left foot) or level of physical activity (p = 0.28 for the right foot and p = 0.96 for the left foot). The variation of the weight discharge plant showed no significant relationship with age (R² = 0.2 and p = 0.6). In relation to the influence of physical activity on the weight discharge variation, a significant relationship was observed with the percentages of weight on the anterior and back foot regions at the parallel feet position with EO and EC (Table 3).

Discussion

This study investigated the variation of plantar pressure in women aged between 50 and 88 due to their vision condition, with EO and EC, and its relationship to

Confounders

Confounders such as age, gender, the classification of the morphological structure of the foot were controlled, as well as others that are known to be associated with the variation of plantar pressure: Cognitive level.

Statistical analysis

Statistical calculations were performed using IBM SPSS package version 23.0 (IBM, Chicago, USA). To assess the comparation of the variation of plantar pressure and vision influence, we used the paired-samples T-Test and Chi-square Test to assess the comparation of variation of plantar pressure and physical activity. For the comparative analysis of age and foot type in relation to plantar pressure, we used the Bonferroni analysis of variance (ANOVA). Linear regression was

Figure 1: Staheli index.
Line A - Horizontal line at half of the isthmus soles.
Line B - Horizontal line at half of the impression of the calcaneus.

Figure 2: Staheli index.
Line A - Horizontal line at half of the isthmus soles.
Line B - Horizontal line at half of the impression of the calcaneus.
Table 1: Comparison of the paired-samples T-Test of the groups, classified according to the visual condition and its influence on plantar weight discharge in total sample, sedentary and physically active group, observing the right, left, anterior, and posterior plantar pressure distribution percentage measures in average and standard deviation, adopting a significance of p ≤ 0.01.

| Postural Control | Visual Condition | Total sample (142) | Sedentary (47) | Physically active (95) | t     | p    | t    | p    |
|------------------|------------------|--------------------|---------------|------------------------|-------|------|------|------|
| Parallel feet    |                  |                    |               |                        |       |      |      |      |
|                  | % weight discharge RLL - ave. (SD) (EO) | 52.23 (± 6.0) | 51.60 (± 6.5) | 52.32 (± 5.9) | -1.75 | 0.08 | -1.4 | 0.17 |
|                  | % weight discharge RLL - ave. (SD) (EC) | 52.54 (± 6.2) | 52.02 (± 7.0) | 52.57 (± 6.03) | -1.06 | 0.3  |       |      |
|                  | % weight discharge LLL - ave. (SD) (EO) | 47.73 (± 6.07) | 48.44 (± 6.5) | 47.59 (± 5.9) | 1.5   | 0.13 | 1.5  | 0.14 |
|                  | % weight discharge LLL - ave. (SD) (EC) | 47.46 (± 6.2) | 47.98 (± 7.0) | 47.43 (± 6.03) |        |      | 0.7  | 0.5  |
|                  | % anterior weight discharge - ave. (SD) (EO) | 43.82 (± 8.3) | 42.28 (± 7.0) | 44.38 (± 8.8) | 0.16  | 0.9  | -1.2 | 0.24 |
|                  | % anterior weight discharge - ave. (SD) (EC) | 43.77 (± 7.55) | 42.88 (± 6.8) | 44.15 (± 7.86) |        |      | -0.6 | 0.55 |
|                  | % posterior weight discharge - ave. (SD) (EO) | 56.21 (± 8.3) | 57.72 (± 7.0) | 55.67 (± 8.8) | -0.5  | 0.62 |       |      |
|                  | % posterior weight discharge - ave. (SD) (EC) | 56.23 (± 7.55) | 57.12 (± 6.8) | 55.85 (± 7.86) |        |      |      |      |
| Right semitandem |                  |                    |               |                        |       |      |      |      |
|                  | % weight discharge RLL - ave. (SD) (EO) | 40.0 (± 10.4) | 40.58 (± 9.6) | 39.69 (± 10.71) | -6.5  | 0.0  | -4.8 | 0.0  |
|                  | % weight discharge RLL - ave. (SD) (EC) | 42.5 (± 11.12) | 44.16 (± 9.94) | 41.82 (± 11.62) | -4.74 | 0.0  |       |      |
|                  | % weight discharge LLL - ave. (SD) (EO) | 60.0 (± 10.4) | 59.42 (± 9.62) | 60.27 (± 10.74) | 6.12  | 0.0  | 4.8  | 0.0  |
|                  | % weight discharge LLL - ave. (SD) (EC) | 57.6 (± 11.0) | 55.84 (± 9.94) | 58.28 (± 11.45) |        |      | 4.33 | 0.0  |
|                  | % anterior weight discharge - ave. (SD) (EO) | 49.5 (± 5.6) | 49.95 (± 6.4) | 49.15 (± 5.04) | -1.3  | 0.2  | -0.62| 0.54 |
|                  | % anterior weight discharge - ave. (SD) (EC) | 49.8 (± 5.56) | 50.19 (± 6.09) | 49.59 (± 5.16) |        |      | 1.34 | 0.2  |
|                  | % posterior weight discharge - ave. (SD) (EO) | 50.2 (± 5.56) | 50.05 (± 6.41) | 50.85 (± 5.04) | 1.3  | 0.2  | 0.62 | 0.54 |
|                  | % posterior weight discharge - ave. (SD) (EC) | 50.52 (± 5.6) | 49.81 (± 6.09) | 50.41 (± 5.16) |        |      | 1.34 | 0.2  |
| Left semitandem  |                  |                    |               |                        |       |      |      |      |
|                  | % weight discharge RLL - ave. (SD) (EO) | 64.11 (± 10.0) | 63.00 (± 10.0) | 64.47 (± 10.1) | -6.0  | 0.0  | 3.7  | 0.01 |
|                  | % weight discharge RLL - ave. (SD) (EC) | 61.8 (± 10.74) | 60.93 (± 11.08) | 62.11 (± 10.66) | -3.7  | 0.01 | 4.44 | 0.0  |
|                  | % weight discharge LLL - ave. (SD) (EO) | 35.96 (± 10.03) | 37.00 (± 10.02) | 35.63 (± 10.13) | -5.72 | 0.0  | -3.7 | 0.01 |
|                  | % weight discharge LLL - ave. (SD) (EC) | 38.20 (± 10.74) | 39.07 (± 11.08) | 37.89 (± 10.66) |        |      | 4.44 | 0.0  |
|                  | % anterior weight discharge - ave. (SD) (EO) | 47.8 (± 7.0) | 47.26 (± 7.08) | 47.99 (± 6.92) | -0.7  | 0.5  | -1.68| 0.09 |
|                  | % anterior weight discharge - ave. (SD) (EC) | 48.0 (± 6.64) | 48.12 (± 7.0) | 47.85 (± 6.6) |        |      | 4.83 | 0.63 |
|                  | % posterior weight discharge - ave. (SD) (EO) | 52.3 (± 6.85) | 52.74 (± 7.08) | 52.11 (± 6.86) | 0.95  | 0.34 | 1.68 | 0.09 |
|                  | % posterior weight discharge - ave. (SD) (EC) | 52.02 (± 6.64) | 51.88 (± 7.0) | 52.15 (± 6.6) |        |      | 0.13 | 0.9  |

Note: SD: Standard deviation; ave.: Average; NA: Not applicable; RLL: Right lower limb; LLL: Left lower limb; EO: Eyes open; EC: Eyes closed.
Table 2: Comparison of the groups according to the ANOVA test, classified according to the morphological foot type and its influence on weight discharge, observing the right, left, anterior, posterior, and average plantar pressure percentage distribution and standard deviation, adopting a significance level of $p \leq 0.01$.

| Postural Control          | Right foot                  | F | p | Post hoc | Left foot                  | F | p | Post hoc |
|---------------------------|-----------------------------|---|---|----------|-----------------------------|---|---|----------|
|                           | Neutral foot (n = 14)       |   |   |          | Pronated foot (n = 101)     |   |   |          |
|                           | Supinated foot (n = 27)     |   | 0.75 | 0.47 | Neutral foot (n = 20)      |   |   |          |
|                           |                             |   | NA | 52.55 (± 6.27) | 52.1 (± 5.73) | 52.32 (± 6.52) | 0.05 | 0.95 | NA       |
|                           |                             |   | 0.68 | 0.5 | 47.45 (± 6.27) | 47.8 (± 5.85) | 47.71 (± 6.53) | 0.02 | 0.97 | NA       |
|                           |                             |   | 1.56 | 0.21 | 42.4 (± 7.66) | 43.35 (± 8) | 43.49 (± 9.24) | 0.48 | 0.61 | NA       |
|                           |                             |   | 1.52 | 0.22 | 57.6 (± 7.66) | 55.73 (7.94) | 56.49 (± 9.25) | 0.44 | 0.64 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 53.93 (± 5.22) | 52.18 (± 6.04) | 51.52 (± 6.3) | 0.75 | 0.47 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 46.14 (± 5.26) | 47.74 (± 6.13) | 48.48 (± 6.3) | 0.68 | 0.5 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 44.21 (± 9.58) | 44.45 (± 8.34) | 41.3 (± 7.2) | 1.56 | 0.21 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 55.71 (± 9.62) | 55.61 (± 8.3) | 58.7 (± 7.2) | 1.52 | 0.22 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 55.14 (± 6.47) | 52.52 (± 6.13) | 51.26 (± 6.08) | 1.83 | 0.16 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 44.86 (± 6.47) | 47.48 (± 6.13) | 48.74 (± 6.08) | 1.83 | 0.16 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 44.36 (± 8.95) | 44.05 (± 7.74) | 42.44 (± 6.06) | 0.52 | 0.59 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 55.64 (± 8.95) | 55.95 (7.74) | 57.56 (± 6.06) | 0.52 | 0.59 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 38.86 (± 12.03) | 40.56 (± 10.49) | 38.37 (± 9.1) | 0.56 | 0.57 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 61.14 (± 12.03) | 59.4 (± 10.51) | 61.63 (± 9.1) | 0.58 | 0.55 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 49.86 (± 5.14) | 49.46 (± 5.41) | 49.37 (± 6.53) | 0.38 | 0.96 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 50.14 (± 5.14) | 50.54 (± 5.41) | 50.63 (± 6.53) | 0.38 | 0.96 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 39.36 (± 14.93) | 43.42 (± 11.01) | 40.70 (± 9) | 1.25 | 0.28 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 60.64 (± 14.93) | 56.88 (± 10.85) | 59.3 (± 9) | 1.21 | 0.3 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 49.5 (± 4.53) | 49.91 (± 5.5) | 49.56 (± 6.4) | 0.66 | 0.93 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 50.5 (± 4.53) | 50.09 (± 5.5) | 50.44 (± 6.4) | 0.66 | 0.93 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 69.07 (± 7.16) | 64.06 (± 9.5) | 61.74 (± 12.28) | 2.53 | 0.08 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 30.93 (± 7.16) | 36.04 (± 9.53) | 38.26 (± 12.28) | 2.53 | 0.08 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 50.64 (± 5.28) | 46.87 (± 7.18) | 49.78 (± 5.84) | 3.31 | 0.03 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 49.36 (± 5.28) | 53.13 (± 7.18) | 50.59 (± 5.84) | 2.94 | 0.05 | NA       |
|                           | % weight discharge RLL - ave. (SD) |   | 67.29 (± 11.35) | 61.71 (± 10) | 59.26 (± 12.36) | 2.64 | 0.07 | NA       |
|                           | % weight discharge LLL - ave. (SD) |   | 32.71 (± 11.35) | 38.29 (± 10) | 40.74 (± 12.36) | 2.64 | 0.07 | NA       |
|                           | % anterior weight discharge - ave. (SD) |   | 50.36 (± 4.95) | 47.23 (± 6.87) | 49.56 (± 6.13) | 2.34 | 0.09 | NA       |
|                           | % posterior weight discharge - ave. (SD) |   | 49.64 (± 4.95) | 52.77 (± 6.87) | 50.44 (± 6.13) | 2.34 | 0.09 | NA       |

Note: SD: Standard deviation; ave.: Average; NA: Not applicable; RLL: Right lower limb; LLL: Left lower limb.
of the feet when forming the support base, are factors that can worsen postural instability in a population that already tends to have it reduced [2,27].

Results of the reliability study using baropodometry for the evaluation of plantar load distribution reported that neither a heavy working activity nor a session of stretching exercises could cause detectable alterations in the foot plantar pressure distribution in normal subjects [12]. The literature points to the practice of physical activity as a great ally in preventing the harmful effects of aging, especially when these activities are prescribed individually and with a multidisciplinary team, providing improved motor control and associated visuospatial learning [28-30].

| Postural Control                          | Activity Level                      | Physically active (95) | t    | p     |
|-------------------------------------------|-------------------------------------|------------------------|------|-------|
| Parallel feet, eyes open                  |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 53.43 (± 5.95)                      | 51.63 (± 5.98)         | 1.69 | 0.09  |
| % weight discharge LLL - ave. (SD)        | 46.6 (± 5.93)                       | 48.28 (± 6.1)          | -1.58| 0.12  |
| % anterior weight discharge - ave. (SD)   | 41.60 (± 7)                        | 44.93 (± 8.7)          | -2.46| 0.02  |
| % posterior weight discharge - ave. (SD)  | 58.38 (± 7)                        | 55.14 (± 8.7)          | 2.39 | 0.02  |
| Parallel feet, eyes closed                |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 53.64 (± 6.3)                      | 52.0 (± 6.1)           | 1.47 | 0.14  |
| % weight discharge LLL - ave. (SD)        | 46.36 (± 6.3)                      | 48.0 (± 6.1)           | -1.47| 0.14  |
| % anterior weight discharge - ave. (SD)   | 41.74 (± 6.85)                     | 44.78 (± 7.72)         | -2.38| 0.02  |
| % posterior weight discharge - ave. (SD)  | 58.26 (± 6.85)                     | 55.22 (7.72)           | 2.38 | 0.02  |
| Right semitandem, eyes open               |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 38.64 (± 10.52)                    | 40.64 (± 10.29)        | -1.07| 0.28  |
| % weight discharge LLL - ave. (SD)        | 61.36 (± 10.52)                    | 59.32 (± 10.31)        | 1.1  | 0.27  |
| % anterior weight discharge - ave. (SD)   | 48.62 (± 6.45)                     | 49.91 (± 5.07)         | -1.2 | 0.23  |
| % posterior weight discharge - ave. (SD)  | 51.38 (± 6.45)                     | 50.09 (± 5.07)         | 1.2  | 0.23  |
| Right semitandem, eyes closed             |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 40.89 (± 10.63)                    | 43.29 (± 11.33)        | -1.24| 0.22  |
| % weight discharge LLL - ave. (SD)        | 59.11 (± 10.63)                    | 56.81 (± 11.16)        | 1.2  | 0.24  |
| % anterior weight discharge - ave. (SD)   | 49.09 (± 6.4)                      | 50.16 (± 5.1)          | -1.0 | 0.32  |
| % posterior weight discharge - ave. (SD)  | 50.91 (± 6.4)                      | 49.84 (± 5.1)          | 1.0  | 0.32  |
| Left semitandem, eyes open                |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 65.57 (± 10.3)                     | 63.39 (± 9.84)         | 1.2  | 0.23  |
| % weight discharge LLL - ave. (SD)        | 34.43 (± 10.3)                     | 36.72 (± 9.86)         | -1.26| 0.21  |
| % anterior weight discharge - ave. (SD)   | 47.64 (± 7.65)                     | 47.87 (± 6.54)         | -0.18| 0.86  |
| % posterior weight discharge - ave. (SD)  | 52.36 (± 7.65)                     | 52.23 (± 6.47)         | 0.1  | 0.92  |
| Left semitandem, eyes closed              |                                     |                        |      |       |
| % weight discharge RLL - ave. (SD)        | 64.04 (± 10.86)                    | 60.68 (± 10.56)        | 1.75 | 0.08  |
| % weight discharge LLL - ave. (SD)        | 35.96 (± 10.86)                    | 39.32 (± 10.56)        | -1.75| 0.08  |
| % anterior weight discharge - ave. (SD)   | 48.55 (± 7.22)                     | 47.69 (± 6.36)         | 0.7  | 0.49  |
| % posterior weight discharge - ave. (SD)  | 51.45 (± 7.22)                     | 52.31 (± 6.36)         | -0.7 | 0.49  |

Note: SD: Standard deviation; ave.: Aaverage; NA: Not applicable; RLL: Right lower limb; LLL: Left lower limb.

Physical activity. The results show significant alterations in the variation of plantar pressure with changing visual condition and the support base. It was observed that physical activity can influence how weight is discharged in the support base of the human body, but not enough to reduce the influence of the visual condition.

Studies claim that the limit of stability, a concept frequently associated with base of support. It consists of the proportion of the base of support that an individual is able to use while remaining stable. Its characteristics are expressively reduced during the aging process, while the base of support does not change as much [2]. With the reduced stability limit, factors such as the visual condition [11] and the change in the positioning of the feet when forming the support base, are factors that can worsen postural instability in a population that already tends to have it reduced [2,27].

Results of the reliability study using baropodometry for the evaluation of plantar load distribution reported that neither a heavy working activity nor a session of stretching exercises could cause detectable alterations in the foot plantar pressure distribution in normal subjects [12]. The literature points to the practice of physical activity as a great ally in preventing the harmful effects of aging, especially when these activities are prescribed individually and with a multidisciplinary team, providing improved motor control and associated visuospatial learning [28-30].
At Brasil and other regions the public institucional support for practicing physical activity at a transional age group of women improved functional condition of these individuals [29,31,32]. Our findings report partial agreement to this information, suggesting that the practice of physical activity does not impose changes during the standing position, but rather causes motor adaptations characterized by relatively individual responses to the variation of plantar pressure.

At Brasil and other regions the public institucional support for practicing physical activity at a transional age group of women improved functional condition of these individuals [7,29,31,32]. Our findings report partial agreement and work as complement to this information, suggesting that the practice of physical activity does not impose changes during the standing position, but rather causes motor adaptations characterized by relatively individual responses to the variation of plantar pressure.

The structural foot type did not influence the variation of plantar pressure at this study. According to this find, Taş and Çetim [33] found that plantar pressure distribution is related to the morphology of intrinsic foot muscles while foot muscle stiffness is unrelated. It was identified that physical activity can influence how the body’s weight is discharged in the base of support. At this point, the body mass affects plantar pressure and the morphology of intrinsic foot muscles [12,13,33], complementing the information found in our results.

This study applied hard technology to analyze the plantar pressure, instead of footprint on a grid paper or in a podoscope, which measurement accuracy depends on the researcher’s measurement ability; as a result, reliability and repeatability are generally poor [34,35].

Some studies suggest that there are larger differences between baropodometric systems and force plates when examining the force values being measured. However, when considering the analysis of the pressure distribution, both tools show more appropriate results for the data being collected [13,30,36].

Study Limitations

As a limitation, this study faced the necessity of complementing its information on weight discharge with a complete analysis of the stabilometric information provided by baropodometric evaluation data.

Continuity Suggestions

Future studies could be implemented using weight discharge and stabilometric data in order to evaluate information concerning postural control.

Acknowledgments Section

Conflict of interest

The authors declare no conflict of interest for this article.

Author’s contribution

Hadassa Costa Sousa: Substantial contributions to conception and design, acquisition, analysis and interpretation of data; drafting the article and revising it critically for important intellectual content; and final approval of the version to be published.

Martina Estevam Brom Vieira: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Marina Ferreira Moreira: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Juliane Leite Orcino: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Gulherme Augusto Santos Bueno: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Thiago Vilela Lemos: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Cibelle Kayene Martins Roberto Formiga: Conception and design of the study, acquisition and interpretation of data, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Flávia Martins Gervásio: Conception and design of the study, revising the manuscript critically for important intellectual content, final approval of the version to be published.

Sponsor’s role

No sponsor participated.

Acknowledgments

We acknowledge all the subjects who participated in this study, and we thank the Dr. Claudio de Almeida Borges Movement Analysis Laboratory team for their work and support.

Highlights

- Variation in plantar weight bearing is not influ-
enced by the structural type of the foot.
- The visual condition is an able factor of affecting the variation in plantar weight.
- The morphological type of foot showed no relationship with age or level of practice of physical activity
- The variation of the weight discharge plant showed no relationship with age.
- The practice of physical activity do not impose changes during standing position, but rather cause motor adaptations characterized by relatively individual responses in the variation of plantar pressure.

References

1. Caravaggi P, Matias AB, Taddei UT, Ortolani M, Leardini A, et al. (2019) Reliability of medial-longitudinal-arch measures for skin-markers based kinematic analysis. J Biomech 88: 180-185.

2. Duarte M, Freitas SM (2010) Revision of posturography based on force plate for balance evaluation. Rev Bras Fisioter 14: 183-192.

3. Rosário JL (2014) A review of the utilization of baropodometry in postural assessment. J Bodyw Mov Ther 18: 215-219.

4. Bellizzi M, Rizzo G, Bellizzi G, Ranieri M, Fanelli M, et al. (2011) Electronic baropodometry in patients affected by ocular torticollis. Strabismus 19: 21-25.

5. Chow TH, Chen YS, Wang JC (2018) Characteristics of planar pressures and related pain profiles in elite sprinters and recreational runners. J Am Podiatr Med Assoc 108: 33-44.

6. Rodríguez-Sanz D, Tovaruela-Carrion N, López-López D, Palomo-López P, Romero-Morales C, et al. (2018) Foot disorders in the elderly: A mini-review. Dis Mon 64: 64-91.

7. IBGE (2016) Síntese de Indicadores Sociais. Vol 39.

8. Garman CR, Franck CT, Nussbaum MA, Madigan ML (2015) A bootstrapping method to assess the influence of age, obesity, gender, and gait speed on probability of tripping as a function of obstacle height. J Biomech 48: 1229-1232.

9. Gervásio FM, Santos GA, Ribeiro DM, Menezes RL de (2016) Medidas tempo-espaçais indicativas de quedas em mulheres saudáveis entre 50 e 70 anos avaliadas pela análise tridimensional da marcha. Fisioterapia e Pesquisa 23: 358-364.

10. Weeks DL, Borrousch S, Bowen A, Hepler L, Osterfoss M, et al. (2005) The influence of age and gender of an exercise model on self-efficacy and quality of therapeutic exercise performance in the elderly. Physiotherapy Theory Pract 21: 137-146.

11. Machado ÁS, Bombach GD, Duysens J, Carpes FP (2016) Differences in foot sensitivity and plantar pressure between young adults and elderly. Arch Gerontol Geriatr 63: 67-71.

12. Baumfeld D, Baumfeld T, da Rocha RL, Macedo B, Raduan F, et al. (2017) Reliability of baropodometry on the evaluation of plantar load distribution: A transversal study. Biomed Res Int 2017: 5925137.

13. Castro MP de, Soares D, Machado L (2011) Comparison of vertical GRF obtained from force plate, pressure plate and insole pressure system. 29 International Conference on Biomechanics in Sports, ISBS, 849-852.

14. da Silva PJG, Nadal J, Infantosy AFC (2012) Investigating the center of pressure velocity Romberg's quotient for assessing the visual role on the body sway. Rev Bras Eng Bioméd 28: 319-326.

15. Lanska DJ, Goetz CG (2000) Romberg's sign: Development, adoption, and adaptation in the 19th century. Neurology 55: 1201-1206.

16. Melo RS, Marinho SEDS, Freire MEA, Souza RA, Dama-sceno HAM, et al. (2017) Static and dynamic balance of children and adolescents with sensorineural hearing loss. Einstein (Sao Paulo) 15: 262-268.

17. Pita-Fernández S, González-Martín C, Seoane-Pillado T, López-Calviño B, Pértega-Díaz S, et al. (2015) Validity of footprint analysis to determine flatfoot using clinical diagnosis as the gold standard in a random sample aged 40 years and older. J Epidemiol 25: 148-154.

18. Hernandez AJ, Kimura LK, Laraya MHF, Fávaro E (2007) Cálculo do Índice do arco plantar de staheli e a prevalência de pés planos: Estudo em 100 crianças entre 5 e 9 anos de idade. Acta Ortop Bras 15: 68-71.

19. Hillstrom HJ, Song J, Kraszewski AP, Hafer JF, Mootanah R, et al. (2013) Foot type biomechanics part 1: Structure and function of the asymptomatic foot. Gait Posture 37: 445-451.

20. Folstein MF, Folstein SE, McHugh PR (1975) “Mini-mental state”. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12: 189-198.

21. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Oka-moto IH (2003) Sugestões para o uso do mini-exame do estado mental no Brasil. Arq Neuro Psiquiatr 61: 777-781.

22. Chaves MLF (2008) Testes de avaliação cognitiva: Mini-Exame do Estado Mental. In: Universidade Federal do Rio Grande do Sul, 30.

23. Mazo GZ, Benedetti TRB (2010) Adaptação do questionário internacional de atividade física para idosos. Rev Bras Cineantropom Desempenho Hum 12: 480-484.

24. Giacomozzi C, Keijers N, Pataky T, Rosenbaum D (2012) International scientific consensus on medical plantar pressure measurement devices: Technical requirements and performance. Ann Ist Super Sanità 48: 259-271.

25. Staeheli LT, Chew DE, Corbett M (1987) The longitudinal arch. A survey of eight hundred and eighty-two feet in normal children and adults. J Bone Joint Surg Am 69: 426-428.

26. Zuil-Escobar JC, Martínez-Cepa CB, Martín-Urrialde JA, Gómez-Conesa A (2019) Evaluating the medial longitudinal arch of the foot: Correlations, reliability, and accuracy in people with a low arch. Phys Ther 99: 364-372.

27. Buldt AK, Forghany S, Landorf KB, Murley GS, Levinger P, et al. (2018) Centre of pressure characteristics in normal, planus and cavus feet. J Foot Ankle Res 11: 3.

28. Pereira T, Cipriano I, Costa T, Saraiva M, Martins A, et al. (2019) Exercise, ageing and cognitive function - Effects of a personalized physical exercise program in the cognitive function of older adults. Physiol Behav 202: 8-13.

29. Estrela AL, Bauer ME (2010) Envelhecimento saudável e atividade física: Uma revisão sistemática sobre os efeitos do exercício nas doenças cardiovasculares. Sci Medica Rev 27: 1-7.

30. Jönsson M, Munkhammar T, Norbrand L, Berg HE (2019) Foot centre of pressure and ground reaction force during quadriceps resistance exercises; A comparison between force plates and a pressure insole system. J Biomech 87: 206-210.
31. Tomicki C, Zanini SCC, Cecchin L, Benedetti TRB, Portella MR, Leguisamo CP (2016) Efeito de um programa de exercícios físicos no equilíbrio e risco de quedas em idosos institucionalizados: Ensaio clínico randomizado. Rev Bras Geriatr Gerontol 19: 473-482.

32. Vagetti GC, Oliveira V de, Silva MP, Pacifico AB, Costa TRA, et al. (2017) Associação do índice de massa corporal com a aptidão funcional de idosas participantes de um programa de atividade física. Rev Bras Geriatr Gerontol 20: 216-227.

33. Tas S, Çetin A (2019) An investigation of the relationship between plantar pressure distribution and the morphologic and mechanic properties of the intrinsic foot muscles and plantar fascia. Gait Posture 72: 217-221.

34. Chun S, Kong S, Mun KR, Kim J (2017) A foot-arch parameter measurement system using a RGB-D camera. Sensors (Basel) 17: 1796.

35. Rodolfo Maestre-Rendon J, Rivera-Roman TA, Sierra-Hernandez JM, Cruz-Aceves I, Contreras-Medina LM, et al. (2017) Low computational-cost footprint deformities diagnosis sensor through angles, dimensions analysis and image processing techniques. Sensors (Basel) 17.

36. Golriz S, Hebert JJ, Foreman KB, Walker BF (2012) The validity of a portable clinical force plate in assessment of static postural control: Concurrent validity study. Chiropr Man Therap 20: 15.