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Effect of visual condition and physical activity on the plantar pressure distribution in adult and older women

Efeito do sistema visual e atividade física na distribuição da pressão plantar em mulheres adultas e idosas

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Abstract – The aging process causes changes in the physical and functional conditions, as well as in the foot structure and function. This study aimed to analyze the plantar pressure variation with respect to visual information and physical activity in adult and older women. This was a cross-sectional study that included 142 women (mean age of 67.8 years). Participants responded the anamnesis questionnaire, Mini Mental State Examination, and International Physical Activity Questionnaire. Plantar pressure was assessed using computerized baropodometry. Weight distribution was observed in semitandem positions for the right foot forward and then the left foot forward . Data analysis showed that foot type had no correlation with age (p = 0.37 right foot; p = 0.93 left foot) or level of physical activity (p = 0.28 right foot; p = 0.96 left foot). Moreover, plantar pressure variation showed no significant relationship with age (R^2 = 0.2; p = 0.6). In conclusion, plantar pressure variation is not associated with the morphological foot type in women analyzed, as the visual condition did not generate plantar pressure variations when compared to its effect on the classification of plantar arches. Furthermore, level of physical activity was not associated with plantar pressure variation.

Key words: Aged; Foot; Postural balance; Plantar pressure; Women.

Resumo – *O processo de envelhecimento acarreta alterações nas condições físico-funcionais e na estrutura e função do pé. O objetivo do estudo foi analisar a variação da pressão plantar quanto a informação visual e atividade física em mulheres adultas e idosas. Estudo transversal, com uma amostra de 142 mulheres (média de idade de 67,8 anos). As mulheres responderam ao questionário de anamnese, Mini Exame do Estado Mental (MEEM) e o Questionário Internacional de Atividade Física (IPAQ). O exame da pressão plantar foi realizado pela baropodometria computadorizada. A distribuição da pressão plantar foi observada na posição semitandem com o pé direito na frente e com o pé esquerdo à frente. O tipo de pé não teve relação com a variação da pressão plantar, idade (p = 0,37 pé direito e p = 0,93 pé esquerdo) ou atividade física (p = 0,28 pé direito e p = 0,96 pé esquerdo). A variação da pressão plantar também não mostrou relação significativa com idade (R2 = 0,2 e p = 0,6). Conclui-se que a variação da pressão plantar não está associada com o tipo morfológico do pé das mulheres analisadas, pois a condição visual não gerou variação da pressão plantar quando comparada ao seu efeito na classificação dos arcos plantares. O nível de atividade física não apresentou relação na variação da pressão plantar.*

Palavras-chave: *Equilíbrio postural; Idosas; Mulheres; Pé; Pressão plantar.*

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INTRODUCTION

The aging process causes biomechanical, structural, and functional foot changes and is associated with impaired mobility and falls[1]. Together with the musculoskeletal and ligamentous foot structures, the weight-bearing properties in static postures comprise an important proprioception-return mechanism and play a major role in transferring and dampening forces across the foot during dynamic tasks[2].

The number of adult and older adult women is higher than that of men in the general Brazilian population[3] It was demonstrated that women are at increased risk of more frequent tripping and falling than age-matched men[4]. However, there is lack of studies in Brazilian and international literature verifying changes in static postural balance related to the quality of therapeutic exercise performed by women in the transition between adult and older ages[5].

The maintenance of this balance is important for performing dynamic daily life activities and practicing physical activities[6]. The discharge of the body weight into the support base is affected by several factors. These factors are classified as intrinsic factors, such as physiological disturbances, anthropometric characteristics, and physical condition, and extrinsic factors, such as gravity, erratic ground, and environment[7].

These factors can generate a state of imbalance, leading to functional overload on the musculoskeletal system and causing sensory and nervous system dysfunction. Changes in balance lead to the onset of pathological clinical problems that may be associated with diseases and deformities affecting the feet, such as pain, stress fractures, and callosities[8].

There are several studies extensively discussing plantar pressure[9–11]. However, there is lack of studies in current literature on the relationship between visual condition, age, and physical activity and plantar pressure variations in older adults and those in the transition between adult and older ages[2,12].

The biomechanical mechanisms of the foot are responsible for maintaining plantar pressure distribution. The most common and reliable tools to study plantar pressure distribution are the force plate and baropodometric platforms[13]. The literature shows a variety of protocols to use these tools. This study adopted the Romberg's protocol, which is used to investigate the visual feedback associated with body sway control[14].

Baropodometry is an advanced pressure platform method that maps the plantar surface pressure to analyze plantar pressure areas of the body in both static and dynamic tasks. Its software produces images similar to those of a podoscope, providing information regarding distribution of loads in the standing position, peak pressure, detection of the risk of pressure sores on the feet, as well as stabilometric information[7,13].

As compared to men, adult and older women practice physical activities more frequently. This habit is beneficial in several bodily aspects and as a health indicator (5,6). As for motor performance, it is not yet clear whether

the practice of physical activity influences plantar pressure variations and foot morphology. This indicator may be important for assessing balance in this age group and as a long-term health predictor[9,10].

Therefore, this study aimed to analyze plantar pressure variations due to visual conditions with eyes open (EO) or eyes closed (EC), and its relationship with physical activity in women aged 50 years and older.

METHOD

Study Design

This was a cross-sectional study approved by the Research Ethics Committee of the Goiás Federal University, decision number 3.646.405/2019. All participants provided written informed consent.

Sample

This study used the convenience sampling technique, where women practicing physical activities in the Open University of the Third Age Program (OUTA) were invited to participate. After data collection, sample size was calculated using the G*Power 3.1.9.2 software, considering 95% confidence interval and power of 95% (type II error) for plantar pressure distribution with effect size of 0.481 and significance level of 0.01 (type I error). The required sample size was 145. The parameters used were based on previous studies with samples including the adult and older population[5,15,16].

All participants were physically independent women with minimum of age of 50 years. Participants had no history of lower limb, pelvic, or spinal surgery, and no medical diagnosis of rheumatoid arthritis, neuromuscular or neurodegenerative diseases, or diabetes mellitus, had no visual impairment, no alcohol ingestion 24 hours prior to data collection. Considering educational level, all participants scored >24 on the Mini-Mental State Examination (MMSE)[17], while illiterate participants scored >14 points[18]. Exclusion criteria were women with acute injuries in lower limbs or health problems that impaired examinations.

Procedures

Participants responded the anamnesis questionnaire that provided information such as name, age and health conditions. To assess cognitive state, MMSE was used[19], whereas the International Physical Activity Questionnaire (IPAQ) was applied to assess physical ability[20]. Data regarding weight and pressure discharge areas were provided by the Foot Work® baropodometry software equipped with quartz sensors capturing at frequency of 150 Hz[21]. These data were used to assess the balance and classification of morphological foot types.

Three postures were adopted for plantar pressure analysis: first, orthostatic feet on normal base (side by side); second, semitandem position with right foot forward ; and third, semitandem position with left foot forward . In each posture, participants kept their eyes open for 60 seconds (EO)

and then maintained the same position with their eyes closed (EC), thus providing six conditions for the evaluation for each participant according to the Romberg's protocol[22].

Foot types were classified according to methodology described here. The full-size foot image obtained in the plantar pressure platform was exported using the CorelDRAW® 2018 software. Two straight lines were drawn on the image with a computer mouse: one horizontal line at half of the isthmus soles (line A), and another at half of the calcaneus impression (line B) (Figure 1).

Figure 1. Staheli index.
Line A: Horizontal line at half of the isthmus soles; Line B: Horizontal line at half of the calcaneus impression[23]

The classification of the morphological foot structure followed the Staheli index as described by Zuil-Escobar et al.[24]. This index divides values of lines A and B (measured in cm). Based on these values, foot was classified as neutral (0-3.1 cm), pronated foot (>1 cm), or supinated foot (<0.3 cm). Evaluation procedures were conducted in a single visit and required approximately 1 hour. The entire evaluation was performed by experienced and trained physiotherapist.

Confounders

Confounders such as age and classification of the morphological foot structure were controlled, which are known to be associated with plantar pressure variations [18,25].

Statistical analysis

Statistical calculations were performed using the IBM Statistical Package for the Social Sciences (SPSS version 23.0; IBM, Chicago, USA), and data normality was verified using the Shapiro-Wilk test. The paired-samples t-test was used to assess the comparison between plantar pressure variation and visual condition among groups, and the chi-square test to assess the comparison between plantar pressure variation and physical activity. For the comparative analysis of age and foot type in relation to plantar

pressure, one-way analysis of variance and Bonferroni post-hoc test were used. Simple linear regression was applied to analyze the relationship between age and plantar pressure, and the independent t-test to analyze the relationship between plantar pressure and physical activity. The standard significance level adopted for all comparisons was 5% ($p < 0.05$).

RESULTS

During the study period, 150 women were deemed eligible to participate in the study, of which eight were excluded for presenting inadequate data to classify their foot type. The sample composed of 142 patients was divided into two groups considering median age: adult women (50-65 years old) and older women (66-88 years old). Characterization data are shown in Table 1.

Table 1. Characteristics of adult and older adult women participating in the study.

Items	Adult women (n = 57)	Older adult women (n = 85)
Age	60.42 (±3.66)	72.9 (±5.1)
BMI	27.2 (±4)	26.6 (±4.5)
IPAQ	2.77 (±0.8)	2.75 (±0.93)
MMSE	27.5 (±3.13)	26.83 (±3.43)

Note. BMI, body mass index; IPAQ, International Physical Activity Questionnaire; MMSE, Mini-Mental State Examination; Data are presented as mean (±standard deviation).

The relationship between visual stimulus and plantar pressure discharge distribution was observed in the semitandem position with the right foot forward and semitandem position of the left foot forward. This result was observed throughout the sample regardless of whether the individual was physically active or sedentary (Table 2). Foot types showed no relationship with age or level of physical activity.

Participants classified as normal foot type showed plantar pressure discharge in both lower limbs, with predominance in the right lower limb and posterior foot region. This behavior was also observed for all other foot types. There was predominance of pronation in both feet. There was no statistically significant difference with respect to the effects of visual condition (EO or EC) on foot pressure or foot morphology types considering discharge variations (Table 3).

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

Regression analyses results showed that the morphological foot type had no relationship with age ($p = 0.37$ for the right foot; $p = 0.93$ for the left foot) or level of physical activity ($p = 0.28$ for the right foot; $p = 0.96$ for the left foot). Plantar pressure discharge variations showed no significant relationship with age ($R^2 = 0.2$; $p = 0.6$). Regarding the relationship

Table 2. Paired-samples t-test for the comparison of groups classified according to visual condition and its relationship with plantar pressure discharge.

Postural control	Visual condition											
	Total sample (Mean/SD)	CI (95%)	t	p (r^2)	Sedentary (Mean/SD)	CI (95%)	t	p (r^2)	Physically active (Mean/SD)	CI (95%)	t	p (r^2)
Parallel feet												
% plantar pressure discharge RLL (EO)	52.23 (±6.0)	−0.01-0.0	−1.75	0.08 (0.0)	51.60 (±6.5)	−0.01-0.0	−1.4	0.17 (0.0)	52.32 (±5.9)	−0.01-0.0	−1.06	0.3 (0.0)
% plantar pressure discharge RLL (EC)	52.54 (±6.2)				52.02 (±7.0)				52.57 (±6.03)			
% plantar pressure discharge LLL (EO)	47.73 (±6.07)	−0.0-0.01	1.5	0.13 (0.0)	48.44 (±6.5)	−0.0-0.01	1.5	0.14 (0.0)	47.59 (±5.9)	−0.0-0.0	0.7	0.5 (0.0)
% plantar pressure discharge LLL (EC)	47.46 (±6.2)				47.98 (±7.0)				47.43 (±6.03)			
% anterior plantar pressure discharge (EO)	43.82 (±8.3)	−0.0-0.01	0.16	0.9 (0.0)	42.28 (±7.0)	−0.01-0.0	−1.2	0.24 (0.0)	44.38 (±8.8)	−0.0-0.01	−0.6	0.55 (0.0)
% anterior plantar pressure discharge (EC)	43.77 (±7.55)				42.88 (±6.8)				44.15 (±7.86)			
% posterior plantar pressure discharge (EO)	56.21 (±8.3)	−0.0-0.01	−0.05	1.0 (0.0)	57.72 (±7.0)	−0.0-0.01	1.2	0.24 (0.0)	55.67 (±8.8)	−0.01-0.0	−0.5	0.62 (0.0)
% posterior plantar pressure discharge (EC)	56.23 (±7.55)				57.12 (±6.8)				55.85 (±7.86)			
Right semitandem												
% plantar pressure discharge RLL (EO)	40.0 (±10.4)	−0.03-(−0.02)	−6.5	0.0 (0.0)	40.58 (±9.6)	−0.05-(−0.02)	−4.8	0.0 (0.0)	39.69 (±10.71)	−0.03-(−0.01)	−4.74	0.0 (0.0)
% plantar pressure discharge RLL (EC)	42.5 (±11.12)				44.16 (±9.94)				41.82 (±11.62)			
% plantar pressure discharge LLL (EO)	60.0 (±10.4)	0.02-0.03	6.12	0.0 (0.0)	59.42 (±9.62)	0.02-0.05	4.8	0.0 (0.0)	60.27 (±10.74)	0.01-0.03	4.33	0.0 (0.0)
% plantar pressure discharge LLL (EC)	57.6 (±11.0)				55.84 (±9.94)				58.28 (±11.45)			
% anterior plantar pressure discharge (EO)	49.5 (±5.6)	−0.01-0.0	−1.3	0.2 (0.0)	49.95 (±6.4)	−0.01-0.0	−0.62	0.54 (0.0)	49.15 (±5.04)	−0.01-0.0	−1.34	0.2 (0.0)
% anterior plantar pressure discharge (EC)	49.8 (±5.56)				50.19 (±6.09)				49.59 (±5.16)			
% posterior plantar pressure discharge (EO)	50.2 (±5.56)	−0.0-0.01	1.3	0.2 (0.0)	50.05 (±6.41)	−0.0-0.01	0.62	0.54 (0.0)	50.85 (±5.04)	−0.0-0.01	1.34	0.2 (0.0)
% posterior plantar pressure discharge (EC)	50.52 (±5.6)				49.81 (±6.09)				50.41 (±5.16)			
Left semitandem												
% plantar pressure discharge RLL (EO)	64.11 (±10.0)	0.01-0.03	6.0	0.0 (0.0)	63.00 (±10.0)	0.01-0.03	3.7	0.01 (0.0)	64.47 (±10.1)	0.0-0.03	−4.74	0.0 (0.0)
% plantar pressure discharge RLL (EC)	61.8 (±10.74)				60.93 (±11.08)				62.11 (±10.66)			
% plantar pressure discharge LLL (EO)	35.96 (±10.03)	−0.03-(−0.01)	−5.72	0.0 (0.0)	37.00 (±10.02)	−0.03-(−0.01)	−3.7	0.01 (0.0)	35.63 (±10.13)	−0.03-(−0.01)	4.44	0.0 (0.0)
% plantar pressure discharge LLL (EC)	38.20 (±10.74)				39.07 (±11.08)				37.89 (±10.66)			
% anterior plantar pressure discharge (EO)	47.8 (±7.0)	−0.01-0.0	−0.7	0.5 (0.0)	47.26 (±7.08)	−0.02-0.0	−1.68	0.09 (0.0)	47.99 (±6.92)	−0.0-0.0	4.83	0.63 (0.0)
% anterior plantar pressure discharge (EC)	48.0 (±6.64)				48.12 (±7.0)				47.85 (±6.6)			
% posterior plantar pressure discharge (EO)	52.3 (±6.85)	−0.0-0.0	0.95	0.34 (0.0)	52.74 (±7.08)	−0.0-0.02	1.68	0.09 (0.0)	52.11 (±6.86)	−0.0-0.0	0.13	0.9 (0.0)
% posterior plantar pressure discharge (EC)	52.02 (±6.64)				51.88 (±7.0)				52.15 (±6.6)			

Note. The observed percentage distributions of the right, left, anterior, and posterior plantar pressure are represented as mean (±standard deviation) with significance level $p \leq 0.05$; SD, standard deviation; RLL, right lower limb; LLL, left lower limb; EO, eyes open; EC, eyes closed; CI, confidence interval for mean; r^2, effect size

Table 3. One-way analysis of variance test for the comparison of groups classified according to the morphological foot type and its relationship with plantar pressure

Postural control	Right foot			F	p	Left foot			F	p
	Neutral foot (n = 14) (Mean/SD)	Pronated foot (n = 101) (Mean/SD)	Supinated foot (n = 27) (Mean/SD)			Neutral foot (n = 20) (Mean/SD)	Pronated foot (n = 81) (Mean/SD)	Supinated foot (n = 41) (Mean/SD)		
Parallel feet, eyes open										
% plantar pressure discharge RLL	53.93 (±5.22)	52.18 (±6.04)	51.52 (±6.3)	0.75	0.47	52.55 (±6.27)	52.1 (±5.73)	52.32 (±6.52)	0.05	0.95
% plantar pressure discharge LLL	46.14 (±5.26)	47.74 (±6.13)	48.48 (±6.3)	0.68	0.5	47.45 (±6.27)	47.8 (±5.85)	47.71 (±6.53)	0.02	0.97
% anterior plantar pressure discharge	44.21 (±9.58)	44.45 (±8.34)	41.3 (±7.2)	1.56	0.21	42.4 (±7.66)	44.35 (±8)	43.49 (±9.24)	0.48	0.61
% posterior plantar pressure	55.71 (±9.62)	55.61 (±8.3)	58.7 (±7.2)	1.52	0.22	57.6 (±7.66)	55.73 (7.94)	56.49 (±9.25)	0.44	0.64
Parallel feet, eyes closed										
% plantar pressure discharge RLL	55.14 (±6.47)	52.52 (±6.13)	51.26 (±6.08)	1.83	0.16	52.35 (±6)	52.53 (±5.82)	52.66 (±7.06)	0.17	0.98
% plantar pressure discharge LLL	44.86 (±6.47)	47.48 (±6.13)	48.74 (±6.08)	1.83	0.16	47.65 (±6)	47.47 (±5.82)	47.34 (±7.06)	0.17	0.98
% anterior plantar pressure discharge	44.36 (±8.95)	44.05 (±7.74)	42.44 (±6.06)	0.52	0.59	43.1 (±6.8)	43.64 (±7.63)	44.37 (±7.9)	0.21	0.8
% posterior plantar pressure discharge	55.64 (±8.95)	55.95 (7.74)	57.56 (±6.06)	0.52	0.59	56.9 (±6.8)	56.36 (±7.63)	55.63 (±7.9)	0.21	0.8
Right semitandem, eyes open										
% plantar pressure discharge RLL	38.86 (±12.03)	40.56 (±10.49)	38.37 (±9.1)	0.56	0.57	44.6 (±9.6)	39.4 (±10.7)	38.88 (±9.7)	2.39	0.09
% plantar pressure discharge LLL	61.14 (±12.03)	59.4 (±10.51)	61.63 (±9.1)	0.58	0.55	55.4 (±9.6)	60.56 (±10.72)	61.12 (±9.7)	2.36	0.09
% anterior plantar pressure discharge	49.86 (±5.14)	49.46 (±5.41)	49.37 (±6.53)	0.38	0.96	50.25 (±6.78)	49.62 (±5.24)	48.83 (±5.65)	0.49	0.61
% posterior plantar pressure discharge	50.14 (±5.14)	50.54 (±5.41)	50.63 (±6.53)	0.38	0.96	49.75 (±6.78)	50.38 (±5.24)	51.17 (±5.65)	0.49	0.61
Right semitandem, eyes closed										
% plantar pressure discharge RLL	39.36 (±14.93)	43.42 (±11.01)	40.70 (±9)	1.25	0.28	47.9 (±8.24)	41.73 (±11.6)	41.39 (±10.88)	2.82	0.06
% plantar pressure discharge LLL	60.64 (±14.93)	56.68 (±10.85)	59.3 (±9)	1.21	0.3	52.1 (±8.24)	58.4 (±11.4)	58.61 (±10.88)	2.96	0.05
% anterior plantar pressure discharge	49.5 (±4.53)	49.91 (±5.5)	49.56 (±6.4)	0.66	0.93	50.55 (±6.85)	50.05 (±5.4)	48.95 (±5.23)	0.74	0.48
% posterior plantar pressure discharge	50.5 (±4.53)	50.09 (±5.5)	50.44 (±6.4)	0.66	0.93	49.45 (±6.85)	49.95 (±5.4)	51.05 (±5.23)	0.74	0.48
Left semitandem, eyes open										
% plantar pressure discharge RLL	69.07 (±7.16)	64.06 (±9.5)	61.74 (±12.28)	2.53	0.08	63.75 (±9.8)	64.31 (±9.3)	63.9 (±11.61)	0.04	0.96
% plantar pressure discharge LLL	30.93 (±7.16)	36.04 (±9.53)	38.26 (±12.28)	2.53	0.08	36.25 (±9.8)	35.81 (±9.32)	36.1 (±11.61)	0.02	0.98
% anterior plantar pressure discharge	50.64 (±5.28)	46.87 (±7.18)	49.78 (±5.84)	3.31	0.03	50.25 (±6.23)	46.99 (±7.42)	48.2 (±5.9)	1.91	0.15
% posterior plantar pressure discharge	49.36 (±5.28)	53.13 (±7.18)	50.59 (±5.84)	2.94	0.05	49.75 (±6.23)	53.01 (±7.42)	52.05 (±5.72)	1.87	0.16
Left semitandem, eyes closed										
% plantar pressure discharge RLL	67.29 (±11.35)	61.71 (±10)	59.26 (±12.36)	2.64	0.07	61.75 (±9.86)	61.53 (±10)	62.34 (±12.66)	0.07	0.92
% plantar pressure discharge LLL	32.71 (±11.35)	38.29 (±10)	40.74 (±12.36)	2.64	0.07	38.25 (±9.86)	38.47 (±10)	37.66 (±12.66)	0.07	0.92
% anterior plantar pressure discharge	50.36 (±4.95)	47.23 (±6.87)	49.56 (±6.13)	2.34	0.09	49.95 (±6.1)	47.51 (±7)	47.95 (±6.2)	1.09	0.34
% posterior plantar pressure discharge	49.64 (±4.95)	52.77 (±6.87)	50.44 (±6.13)	2.34	0.09	50.05 (±6.1)	52.49 (±7)	52.05 (±6.2)	1.09	0.34

Note. The observed percentage distributions of the right, left, anterior, and posterior plantar pressure are represented as mean (±standard deviation) with significance level $p \leq 0.05$; SD, standard deviation; RLL, right lower limb; LLL, left lower limb.

between physical activity and plantar pressure discharge variation, the percentage of plantar pressure distribution on the anterior and back foot regions in the parallel foot position with EO (eyes open) and EC (eyes closed) was statistically significant (Table 4).

Table 4. T-test comparison of groups classified according to level of physical activity and its relationship with plantar pressure discharge

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

Note. The observed percentage distributions of the right, left, anterior, and posterior plantar pressure are represented as mean (±standard deviation) with significance level $p \leq 0.05$; SD, standard deviation; RLL, right lower limb; LLL, left lower limb

DISCUSSION

This study investigated the plantar pressure variation in women aged 50-88 years based on their visual condition (EO and EC) and its relationship with physical activity. Participants in the adult group and older adult group were overweight and eutrophic, respectively, as well as the body mass index clas-

sification for their respective age groups. This result was expected according to current literature, justified by sarcopenia, decreased lean mass, decreased bone density, and increased adipose tissue due to the aging process[25–27].

Women of both age groups in this study had irregular physical activity. This is consistently found in older adult women of today's society, who look for practicing some type of physical activity that makes them leave the sedentary lifestyle; however, activities do not classify them as performing high-level physical activities due to insufficient intensity and frequency of exercises[26]. In this study, the practice of physical activity was related to plantar pressure discharged on the support base associated with visual condition, as plantar pressure variation is influenced by visual stimulus[13,28].

The parallel position of feet provides greater stability and allows better alignment of the center of gravity between feet[6,12]. The semitandem position simulates step position that tends to create unstable static posture, causing the body to perform compensatory strategies during plantar pressure distribution[6,11,29]. This condition was demonstrated in this study.

Stability limits are affected by the proportion of support base that helps to maintain an individual in the stable position[6,28]. During the aging process, stability limits characteristics significantly reduce, but the support base does not change in a similar way[30]. The reduction of stability limits is associated with other factors that maintain postural control, such as visual condition[12]. There were changes in the feet positioning of support base in the static posture of participants in the transition between adult and older ages in this study, which included factors that worsen postural instability[30].

Our findings suggest that the practice of physical activity does not impose changes in the standing position, but rather causes motor adaptations characterized by relatively individual responses to plantar pressure variations. Physically active individuals tend to show better response to postural instability situations [28,29].

Results of the present study showed that with feet in the semitandem position with EC, there was greater instability in the weight distribution between feet, regardless of physical condition[28,29]. Results of the reliability study using baropodometry for the evaluation of plantar load distribution reported that neither heavy working activity nor a stretching exercise session could cause detectable foot plantar pressure distribution alterations in normal individuals[13].

The literature points to practicing physical activity as a prevention strategy in the aging process, especially when activities are individually prescribed by a multidisciplinary team, which provide improved motor control and associated visuospatial learning[11,25,27]. In Brazil and other regions, public institutional support for practicing physical activity in the transition age for women improved their functional condition[3,26–28]. Our findings partially agree with this information, suggesting that the practice of physical activity does not impose changes in the standing position, but rather causes motor adaptations characterized by relatively individual responses to plantar pressure variations.

The morphological foot type was not associated with plantar pressure variations in this study. According to Taş and Çetim[29], plantar pressure distribution is related to intrinsic foot muscle morphology, while foot muscle stiffness is unrelated. Thus, physical activity may be associated with the way body weight is discharged on the support base. Therefore, body mass affects plantar pressure and the intrinsic muscle foot morphology[13,29], complementing the information found in our results.

This study applied advanced technology to analyze plantar pressure. Usually, footprint on a grid paper or podoscope is used, where measurement accuracy depends on the researcher's measurement ability, and reliability and repeatability are generally poor[10].

Some studies suggest that there are larger differences between baropodometric systems and force plates when examining measured force values. However, when considering the pressure distribution analysis , both tools show appropriate results for data collection[9,11].

The limitation of this study was the necessity of complementing plantar pressure information with a complete analysis of the stabilometric information provided by baropodometric evaluation data. As a cross-sectional study, results obtained in this study should be analyzed with caution, as cause-effect relationships could not be established.

Despite the aforementioned limitations, this study can contribute to the clinical practice of professionals and researches that work with the older population, considering physical activity as a protective factor and prevention for the risk of falls.

CONCLUSION

In conclusion, plantar pressure variation is not associated with the morphological foot type in adult and older women, as the visual condition did not generate plantar pressure variations when compared to its effect on the classification of plantar arches. Furthermore, the level of physical activity was not associated with plantar pressure variations.

Future studies should be carried out using weight discharge and stabilometric data to evaluate postural control information.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee –Federal University of Goiás and protocol (No. 3.646.405/2019) was written in accordance with standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed experiments: HCS, FMG. Performed experiments: HCS, MFM, JLO, GASB. Analyzed data: MEBV, GASB, HCS, FMG. Contributed with reagents/materials/analysis tools: CKMRF, TVL, DMR, FMG. Wrote the paper: HCS, FMG.

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