 

# Effect of unilateral bag use on plantar pressures and static balance in women

*Efeito do uso da bolsa unilateral nas pressões plantares e no equilíbrio estático em mulheres*

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## Abstract

**Introduction:** The increasing insertion of women into the labor market has created a need to adapt handbags, with different sizes and weights, which consequently can overload the musculoskeletal system. **Objective:** To evaluate the effect of using a unilateral bag on plantar pressures and static balance in women. **Methods:** Cross-sectional study, carried out in Fortaleza in 2018. 258 women aged between 18 and 59 years who used a unilateral bag participated in this study. Two questionnaires were applied, targeting sociodemographic variables, life habits, characteristics of bag use and level of physical activity. Height, scapular symmetry, body and bag mass were also measured. A baropodometer was used to assess plantar pressure and static balance with and without the unilateral bag. Independent and paired t-tests were applied to verify the influence of the bag on the variables of interest, using the SPSS Statistics program (version 23.0). **Results:** On the side where the bag was carried, an increase in lateral mass distribution (LMD), foot pressure and surface area, and a decrease in the distance from barycenter ($p < 0.05$) were observed. On the opposite side, a decrease in LMD and an increase in barycenter were detected ($p < 0.05$). In static balance, no differences were observed in the anteroposterior and side-to-side oscillations with bag placement ($p > 0.05$). **Conclusion:** The unilateral bag causes alterations in plantar pressures and ipsilateral barycenter alongside the use of the bag, being a risk factor or aggravation for dysfunctions of the musculoskeletal system and for the occurrence of pain.

**Keywords:** Gait. Postural Balance. Risk factors. Women.

***Resumo***

***Introducão:*** *A crescente inserção das mulheres no mercado de trabalho ocasionou uma necessidade de adaptação das bolsas, com tamanhos e pesos diferentes, que por consequência podem sobrecarregar o sistema musculoesquelético.* ***Objetivo:*** *Avaliar o efeito do uso da bolsa unilateral nas pressões plantares e no equilí-brio estático em mulheres.* ***Métodos:*** *Estudo transversal, realizado na cidade de Fortaleza em 2018. Participaram 258 mulheres com idade entre 18 e 59 anos e que usavam bolsa unilateral. Aplicaram-se dois questionários visando as variáveis sociodemográficas, hábitos de vida, características do uso da bolsa e nível de atividade física. Foram mensuradas estatura, simetria escapular, massa corporal e da bolsa. Utilizou-se baropodômetro para a avaliação das pressões plantares e equilíbrio estático com e sem a bolsa unilateral. Aplicaram-se testes t de amostras independentes e pareado para verificar a influência da bolsa nas variáveis de interesse, pelo programa SPSS Statistics (versão 23.0).* ***Resultados:*** *No lado que a bolsa era carregada foram observados aumento da distribuição de massa lateral (DML), da pressão do pé e da área de superfície e diminuição da distância do baricentro (p < 0,05). No lado oposto foram detectados diminuição da DML e aumento do baricentro (p < 0,05). No equilíbrio estático, não foram verificadas diferenças nas oscilações ântero-posterior e látero-lateral com a colocação da bolsa (p > 0,05).* ***Conclusão:*** *A bolsa unilateral causa alterações nas pressões plantares e no baricentro homolaterais no lado do uso da bolsa, sendo um fator de risco ou agravamento para as disfunções do sistema musculoesquelético e para a ocorrência de dor.*


***Palavras-chave:*** *Marcha. Equilíbrio postural. Fatores de Risco. Mulheres.*

## Introduction

Women's work plays a fundamental role in the construction of their identities today, having a significant meaning in terms of their independence and growing insertion in the labor market.[1] This achievement allowed women to assume several functions in addition to domestic responsibility. Added to the conquest of the professional space is the responsibility imposed on them to be reproducers of the human species, regardless of the conditions that permeate their social world. This generates conflicts that lead them to the obligation of knowing how to reconcile the multiple functions performed.[2]

Due to these changes and to the difficulty of combining the work environment with domestic care, the need to adapt clothing and behavior was linked, making it necessary to use a larger and more resistant bag to store everything that was needed for the countless functions performed.[3]

Excess weight and the method of transporting the bags can lead to an overload of the musculoskeletal system, as a result of changes in the forces that act on the body that lead to alterations in postural alignment, plantar pressures, changes in physiological patterns, reduction of static balance and gait symmetry. All of which can cause the appearance of spinal dysfunctions, limitations in certain movements and musculoskeletal pain.[4,5]

Furthermore, the decrease in the balance ability can be explained by the asymmetrical load distribution due to inadequate bag transport, which causes body adaptations to maintain the center of gravity and induce changes in sensory inputs and in the interaction of information from the vestibular system with the visual receptors and the somatosensory system, which is responsible for the body's orientation about its position in space.[6,7] Proper posture uses a minimum amount of energy throughout the movement and does not generate stress on the joints.[8] When there is an increase in the overload by using the bag, a greater energy demand is established, which increases the risk of musculoskeletal disorders.[9]

In this context, as it is the base of support and propulsion of gait, the foot is considered an important region to be evaluated. Within the functional exams, baropodometry can be considered an important assessment for the early detection of dysfunctions, by obtaining relevant data on postural oscillation, feet contact area, distribution of the pressures and location of its center.[8]

It is known that such variables are useful in identifying functional alterations to elucidate risk factors, such as instability of the center of pressure, discrepancy in the contact area of the feet and excessive increase in plantar pressure. Given the above, this study aimed to evaluate the effect of using a unilateral bag on plantar pressures and static balance in women.

## Methods

Cross-sectional and analytical study, carried out at the University of Fortaleza (UNIFOR), located in the city of Fortaleza, Ceará, Brazil, from April to September of 2018. This study was approved by the UNIFOR ethics committee, under protocol number 2,234,844.

The study population consisted of women, aged between 18 and 59 years, regardless of their work activity. Were included women who were using unilateral bags, regardless of the model at the time of collection of the data and excluded those with a diagnosis of shoulder and/or spinal injury, who declared the use of limb prostheses/orthoses and who carried bags with a mass of less than 1 kg at the time of recruitment.

The sample size was calculated based on the population of women in the city of Fortaleza (n = 1,304, 287), shoulder pain prevalence of 20%,[10] significance of 5% and confidence interval of 95%. The estimated final number was 246 women.

A total of 265 women participated in the study, however, seven were excluded for not having been submitted to all stages of the data collection. Thus, the study was concluded with 258 participants. Those who were present at the institution on the days of collection were selected, by direct invitation and through the dissemination of posters at the institution and on social networks. The participants were given detailed information about the research and signed the free and informed consent form.

After selection and consent, the women were submitted to data collection in two distinct phases in the laboratory. In the first phase, two instruments were applied. The first was a questionnaire that addressed demographic variables (age, schooling and children), life habits (physical activity, hours of sleep and sleeping position) and characteristics of bag use (hand preference, side of use and hours of transport of the bag). The second instrument was the short version of the International Physical Activity Questionnaire (IPAQ), which has eight questions that estimate the time spent weekly and the intensity of physical activity at different times: work, transportation, domestic activities and leisure. The level of physical activity is classified as sedentary, insufficiently active (A and B), active and very active.[11,12]

Subsequently, the symmetry of the shoulder girdle was evaluated by leveling the shoulders by palpation, adopting a standard protocol.[13] Body mass and height were measured to calculate body mass index (BMI) and bag mass. For body and bag mass, a portable digital scale (Plenna® brand) was used, with a capacity of 150 kg and sensitivity of 100 g. For the measurement of the body mass, the participant stood on the center of the scale for equal distribution of weight on both feet, barefoot, with the body erect, arms alongside of the body and head up.[14] The bag mass was measured by placing it on the center of the scale without changing the content.

Height was measured by using a portable vertical stadiometer (Sanny® brand), with a capacity of 2.11 m and sensitivity of 0.5 cm. The participant stood in an upright position, with arms relaxed alongside of the body, barefoot and head up, positioned in the Frankfurt plane and free of ornaments. BMI, calculated by dividing mass (in kilograms) by height (in meters) squared, was classified as overweight: yes ($\geq$ 25.00 kg/m$^2$) and no ($\leq$ 24.99 kg/m$^2$).[15]

In the second phase, the women underwent static balance assessment using a two-meter-long electronic baropodometer (FootWalk Pro, AM CUBE, France), with a sampling frequency of 200 Hz. The analyzes were performed by using the Footwork Pro software version 3.7.0.1 (IST Informatique - Intelligence Service et Tecnique, France). The participants stood in bipodal position, feet aligned with the hips and arms extended alongside of the body, staring fixedly at a previously established point for 20 seconds, following a standard protocol.[16] The evaluations were performed with and without the bag, establishing a 1-minute interval between the analyses, and the bag was placed on the most commonly used shoulder by the participant. This sequence was adopted as standard for all participants.

The following measurements were taken: anterior mass division (AMD), posterior mass division (PMD) and lateral mass division (LMD) right and left (%); maximum pressure (MP) (kpa) and surface area (SA) of the left and right foot (cm$^2$); anteroposterior and side-to-side oscillations of the left, right foot and body (cm); distance from the barycenter to the center of the left and right foot (cm); and location of the highest pressure point (forefoot, midfoot and hindfoot).

Descriptive and inferential statistics were applied using the SPSS program (version 20.0). Categorical variables were described by relative (%) and absolute frequency (n) and numeric variables by mean and standard deviation of the mean. For inferential analysis, some variables were dichotomized based on the weighted means of the variables: categorized age (≤ 25 years old, between 26 to 45 and ≥ 46 years old), schooling (≤ 8 years to complete high school and ≥ 8 years to complete upper body), hours of sleep (< 8h and ≥ 8h), sleeping position (less joint overload for the supine position and greater joint overload for the prone and lateral decubitus position, time spent carrying the bag in hours (≤ 2 and > 2), bag mass (≤ 2 kg and > 2.0 kg) and percentage of bag mass in relation to body mass (%bagmass ≤ 5% and > 5%), calculated by the formula (%bagmass = bag mass x 100/body mass).

To analyze the difference in plantar pressures and static balance when using or not using the bag grouped by which side of the body they were carrying the bag (right, left and both groups), the t test was applied for independent samples. To compare the difference in these parameters on the right and left sides in the assessment with and without the bag, the paired t test was applied, after the Kolmogorov-Smirnov (KS) normality test. A significance level of 5% was adopted.

## Results

With regards to the demographic variables of the participants, a higher proportion of women aged between 18 and 25 years (n = 119; 46.1%) was detected, with a mean age of 30 years (± 10.6), with more than 8 years of study (n = 218; 83.7%) and who had children (n = 171; 66.3%). Regarding life habits, 60.9% (n = 157) practiced some kind of physical activity and 29.8% of these (n = 77) were classified as active, 72.1% (n = 186) slept up to 7 hours a night and 87.2% (n = 225) adopted an inappropriate position while sleeping (Table 1).

BMI averaged 25.59 ± 4.37 kg/m$^2$, with a higher proportion of women without excess weight (n = 134; 51.9%). As for the symmetry of the shoulder girdle, it was observed that 34.1% (n = 88) of the women had elevated shoulders, predominantly the left side (n = 45; 17.7%) (Table 1).

As for the characteristics of the bag use, it was observed that 88.8% (n = 229) of the women presented the right side as a manual preference, 55.4% (n = 143) carried the bag on the right side of the body, 63.2 % (n = 163) carried their bags for 2 hours, 57.8% (n = 149) carried bags weighing more than 2.01 kg and 82.9% (n = 214) carried bags weighing up to 5% of their body mass (Table 2).

**Table 1** - Distribution of female assessments according to demographic variables, lifestyle and shoulder girdle assessment

| **Variables** | **n (%)** |
|---|---|
| Demographic | |
| Age (avarage ± standard deviation) | 30.4 ± 10.6 |
| ≤ 25 years | 119 (46.1) |
| 26 a 45 years | 108 (41.9) |
| ≥ 46 years | 31 (12.0) |
| Education | |
| ≤ 8 years | 42 (16.3) |
| > 8 years | 216 (83.7) |
| Children | |
| Yes | 171 (66.3) |
| No | 87 (33.7) |
| Lifestyle | |
| Physical activity | |
| Yes | 157 (60.9) |
| No | 101 (39.1) |
| Level of physical activity | |
| Sedentary | 101 (39.1) |
| Irregularly active B | 9 (3.5) |
| Irregularly active A | 16 (6.2) |
| Active | 77 (29.8) |
| Very active | 53 (20.5) |
| Non responsive | 2 (0.8) |
| Sleep hours | |
| < 8 | 186 (72.1) |
| ≥ 8 | 72 (27.9) |
| Sleep position | |
| Less articular overload | 29 (11.2) |
| Great articular overload | 225 (87.2) |
| Non responsive | 4 (1.6) |
| Excessive weight | |
| No | 134 (51.9) |
| Yes | 124 (48.1) |
| Assessment of shoulder girdle | |
| Elevated shoulder | |
| Yes | 88 (34.1) |
| No | 170 (65.9) |
| Elevated side (n = 88) | |
| Right | 43 (16.7) |
| Left | 45 (17.4) |

**Table 2** - Distribution of women evaluated according to the characteristics of the bag use

| Variable | n (%) |
|---|---|
| Hand preference | |
| Right | 229 (88.8) |
| Left | 28 (10.9) |
| Ambidextrous | 1 (0.4) |
| Use side of bag | |
| Right | 143 (55.4) |
| Left | 61 (23.6) |
| Both sides | 54 (20.9) |
| Time of bag use (average ± SD) | 2.3 ± 2.0 |
| ≤ 2 hours | 163 (63.2) |
| > 2 hours | 95 (36.8) |
| Bag weight (average ± SD) | 2.3 ± 1.2 |
| ≤ 2 Kg | 109 (42.2) |
| > 2 Kg | 149 (57.8) |
| Bag mass x body mass ratio (%) | |
| ≤ 5 | 214 (82.9) |
| > 5 | 44 (17.1) |

Note: SD = standard deviation.

There was a higher proportion of women who had the point of greatest pressure in the right hindfoot (71.3%; n = 184) and left (80.6%; n=208) in the evaluation without the bag. It was also identified that the use of the bag promoted an increase in this proportion of 3.1% in the right foot and 2% in the left foot (Table 3).

**Table 3** - Distribution of analyzed woman according to the pressure point variable

| Variáveis | Without bag | With bag |
|---|---|---|
| Right pressure point | n (%) | n (%) |
| Forefoot | 68 (26.4) | 59 (22.9) |
| Midfoot | 3 (1.2) | 2 (0.8) |
| Hindfoot | 184 (71.3) | 192 (74.4) |
| Halux | 3 (1.2) | 5 (1.9) |
| Left pressure point | | |
| Forefoot | 41 (15.9) | 35 (13.6) |
| Midfoot | 4 (1.6) | 2 (0.8) |
| Hindfoot | 208 (80.6) | 213 (82.6) |
| Halux | 5 (1.9) | 8 (3.1) |

Regarding the evaluation of AMD and PMD, there was no significant difference when carrying the bag, regardless of the side of the shoulder on where the bag is placed ($p > 0.05$). However, PMD values were significantly higher than AMD values, regardless of the use and side of placement of the bag ($p < 0.05$) (Table 4).

About the LMD, it was detected that the use of the bag on the right side caused an increase in the right LMD ($p < 0.001$) and a decrease in the left LMD ($p < 0.001$). As to the use of the bag on the left side of the body, there was a decrease in LMD on the right side ($p < 0.001$) and an increase in LMD on the left ($p < 0.001$). However, the bag carried on both sides did not promote alterations in the right ($p = 0.945$) and left ($p = 0.677$) LMD. When comparing the right LMD with the left LMD without the bag, there was a significant difference in the group that carried the bag on the right and on the left side ($p < 0.001$ for both). When evaluated with the bag, however, only the group that carried it on the right side showed a significant change ($p < 0.001$) (Table 4).

As for the MP, it was observed that the use of the bag on the right side and on both sides caused an increase in pressure on the right foot ($p < 0.001$ and $p = 0.041$, respectively). With regard to the left MP, no significant changes were observed after bag placement, regardless of the side used ($p > 0.05$). Furthermore, it was detected that while using the bag on the right side, there was a difference between the MP of the right and left feet ($p < 0.001$) (Table 4).

It was possible to verify that the use of the bag on the right side of the body generated an increase in the right SA ($p < 0.001$). Regardless of the use of the bag and the side, the SA of the right foot was higher than the one on the left ($p < 0.05$) (Table 4).

Analyzing the anteroposterior and side-to-side right, left and body oscillations, no significant difference was verified according to the placement of the bag, regardless of the side of the shoulder on which the bag was carried ($p > 0.05$); the same situation was also identified when comparing oscillations on both sides ($p > 0.05$) (Table 4).

In relation to the barycenter assessment, it was observed that the use of the bag promoted a decrease in the distance from the ipsilateral barycenter on the side where the bag was used ($p < 0.05$). However, when the bag was carried on both sides, there were no significant changes in the right ($p = 0.666$) and left ($p = 0.881$) barycenter (Table 4).

**Table 4** - Assessment of plantar pressures and postural balance (baropodometry) of women evaluated in relation to the characteristics of bag use

| Variables | Barometry | | | | | | value-p[a] b-c |
|---|---|---|---|---|---|---|---|
| | Without bag | | | With bag | | | |
| | Right[a] | Left[b] | Both sides[c] | Right | Left | Both sides | |
| Anterior mass distribution (%) | 45.4 ± 9.3 | 45.3 ± 10.0 | 46.0 ± 7.7 | 45.1 ± 8.5 | 44.7 ± 9.4 | 46.4 ± 9.8 | 0.650<br>0.530<br>0.735 |
| Posterior mass distribution (%) | 54.5 ± 9.3 | 54.6 ± 10.0 | 53.9 ± 7.7 | 54.6 ± 8.5 | 55.2 ± 9,4 | 53.0 ± 10.0 | 0.894<br>0.530<br>0.468 |
| p-value# | <0.001* | 0.001* | <0.001* | <0.001* | <0.001* | 0.016* | |
| Right side mass distribution (%) | 52.2 ± 5.5 | 52.9 ± 5.7 | 50.5 ± 5.3 | 54.5 ± 6.3 | 50.3 ± 7.2 | 50.5 ± 7.7 | <0.001<br><0.00*<br>0.945 |
| Left side mass distribution (%) | 47.7 ± 5.5 | 47.0 ± 5.7 | 49.5 ± 5.3 | 45.4 ± 6.3 | 49.6 ± 7.2 | 49.8 ± 7.5 | <0.001<br><0,00*<br>0,677 |
| p-value# | <0.001* | <0.001* | 0.494 | <0.001* | 0.674 | 0.739 | |
| Right maximum pressure (kpa) | 113.0 ± 38.3 | 115.6 ± 37.4 | 104.4 ± 26.9 | 123.7 ± 35.8 | 112.3 ± 29.0 | 115.8 ± 46.1 | <0.000*<br>0.432<br>0.041* |
| Left maximum pressure (kpa) | 110.0 ± 37.9 | 108.6 ± 31.0 | 106.1 ± 35.6 | 109.1 ± 37.8 | 117.0 ± 37.0 | 114.5 ± 39.3 | 0.675<br>0.070<br>0.057 |
| p-value# | 0.358 | 0.145 | 0.764 | <0.001* | 0.402 | 0.873 | |
| Right surface area (cm²) | 83.2 ± 14.5 | 82.0 ± 14.6 | 84.3 ± 14.8 | 86.2 ± 14.4 | 83.5 ± 15.1 | 85.5 ± 14.0 | <0.000*<br>0.099<br>0.170 |
| Left surface area (cm²) | 78.7 ± 14.9 | 77.4 ± 14.6 | 79.8 ± 15.6 | 78.0 ± 16.1 | 80.9 ± 15.9 | 80.9 ± 15.6 | 0.388[a]<br>0.006*<br>0.348 |
| p-value# | < 0.001* | < 0.001* | 0.009* | < 0.001* | 0.018* | 0.004* | |
| Right side oscillation (cm) | 0.4 ± 0.3 | 0.4 ± 0.5 | 0.4 ± 0.3 | 0.4 ± 0.4 | 0.5 ± 0.6 | 0.4 ± 0.2 | 0.096<br>0.555<br>0.992 |
| Left side oscillation (cm) | 0.4 ± 0.4 | 0.4 ± 0.4 | 0.4 ± 0.2 | 0.4 ± 0.4 | 0.7 ± 1.9 | 0.7 ± 1.9 | 0.327<br>0.325<br>0.315 |
| p-value# | 0.723 | 0.941 | 0.368 | 0.475 | 0.289 | 1.00 | |
| Right anteroposterior oscillation (cm) | 2.5 ± 1.2 | 2.7 ± 2.1 | 2.6 ± 1.4 | 2.7 ± 1.6 | 2.8 ± 1.8 | 2.5 ± 1.1 | 0.093<br>0.754<br>0.615 |
| Left anteroposterior oscillation (cm) | 2.4 ± 1.5 | 2.5 ± 1.7 | 2.4 ± 0.9 | 2.5 ± 1.3 | 2.8 ± 2.7 | 2.5 ± 1.0 | 0.411<br>0.481<br>0.699 |
| p-value# | 0.747 | 0.279 | 0.173 | 0.120 | 0.943 | 0.924 | |
| Side body oscillation | 1.5 ± 0.7 | 1.7 ± 1.2 | 1.5 ± 0.6 | 1.5 ± 0.7 | 1.9 ± 1.6 | 1.5 ± 0.8 | 0.475<br>0.412<br>0.916 |
| Anteroposterir body oscillation (cm) | 2.2 ± 0.9 | 2.4 ± 1.7 | 2.3 ± 0.7 | 2.4 ± 1.1 | 2.5 ± 1.4 | 2.3 ± 1.0 | 0.116<br>0.792<br>0.587 |
| Right barycenter (cm) | 7.9 ± 1.7 | 7.7 ± 1.8 | 8.1 ± 1.8 | 7.4 ± 1.7 | 8.0 ± 2.0 | 8.1 ± 1.8 | <0.000*<br>0.127<br>0.666 |
| Left barycenter (cm) | 8.7 ± 1.8 | 8.6 ± 1.7 | 8.3 ± 1.9 | 8.9 ± 1.8 | 8.0 ± 1.5 | 8.3 ± 2.0 | 0.053<br>0.003*<br>0.881 |
| p-value# | <0.001* | <0.001* | 0.461 | <0.001* | 0.876 | 0.527 | |

Note: [a]Bag loaded on the right side; [b]Bag loaded on the left side; [c]Bag loaded in both sides compared to assessment without the bag. *p < 0.05, statistically significant for # compared to the left side in two conditions (without bag and with bag).

In the evaluation carried out in the absence of the bag, it was also observed that the distance from the left barycenter was greater than the one on the right, regardless of the side the bag was carried ($p < 0.001$) (Table 4).

## Discussion

Using a shoulder bag for prolonged periods can have negative effects on the human body. These effects include musculoskeletal misalignment, muscle spasms, and postural asymmetry. Repetitive periods of postural asymmetry can lead to asymmetrical muscle activity, contributing to the development of pain over time.[16]

It is observed that the population of the present research was composed mostly of women in the working age.[10,17] This awakens to the real need for the use of unilateral bags, mainly due to the numerous functions performed by them. Furthermore, in this age group, considered the reproductive period of women, musculoskeletal alterations occur more frequently.[18]

With regards to the practice of physical activity, a previous study carried out with women in the same age group as the sample of the present study, obtained an identical classification regarding the level of physical activity.[19] The research also points out the intrinsic proportional relationship between the level of physical activity and quality of life, awakening to greater tolerance to efforts and often resistance to discomfort caused by external factors.[19]

Despite having good habits, women sleep for less time than the recommended, because according to research, sleep can be affected by hormonal changes both during the menstrual cycle and during pregnancy.[20] In addition, the presence of emotional disorders and excessive social attributions influences the sleep pattern negatively.[20] The literature argues that for the functions of organisms to be reestablished, people need a minimum of 8 hours of sleep per day.[21]

Studies show that most women use handbags with a side handle, predominantly on the right side, weighing approximately 2.9 kg, while keeping the accessory hanging on their shoulder for approximately 30 minutes a day, which corresponds to 5% of their body weight.[22,23] The findings converge with what was found in the present study, which showed similar data in the examined sample. Other research points out, however, that the weight imposed on the body due to the use of the bag has had little effect on posture and muscle activity, while the type of bag and the way it is carried have been shown to significantly affect muscle activity and posture.[22]

Still on how the bag is carried, in the present study there was a predominance of right-handed women and most of them carried the bag on their right shoulder. It is known that individuals with right-hand dominance who wear a bag on the left side demonstrate better weight distribution in the lower extremities; this result suggests that the use of load on the shoulder contralateral to the preferred side is beneficial, thus equalizing the load distribution on the lower extremities.[16]

Gong et al.[24] found that the use of the bag on the right side, during the static position, generates significant changes in the maximum pressures of both feet, being greater in the right foot and with weight starting at 5 kg. This result corroborates the finding of the present study, considering that the change in MP was also more significant on the right foot, with greater concentration in the hindfoot region and in women who carried the bag on the right side.

As for the mass, the present study points out that most of the evaluated women had bags with a mass greater than 2.01 kg, being in this group those who carried a bag with a mass of 5 kg or more. When people walk with a heavy bag over their shoulder or on their hand, the foot on the same side has a greater ground reaction force than the opposite foot, increasing the asymmetry.[25,26]

Normal values of plantar pressure distribution are around 60% in the posterior region and 40% in the anterior region of the feet; such distribution can undergo significant changes, mainly in exposure to extrinsic factors such as wearing high heels, which modifies the values, reaching a pressure of up to 80% in the anterior region of the foot and 20% in the posterior region.[27]

Regarding the use of the bag, Pasini Neto et al.[28] pointed out an imbalance regarding the mass distribution, highlighting a higher prevalence of load on the anterior region than on the posterior. The findings of the present study, however, show that although there is no significant difference of mass distribution, when the bag is placed, the PMD values were higher, with a tendency towards anterior displacement of the center of mass. Taking into account that the body mass distributed over the plantar area provides alignment to the pelvis and spine, it is to be expected that an asymmetric distribution, resulting from different forms of load transport, generates changes in the center of mass and plantar pressures.[16,29]

During the imposition of asymmetric load by the use of the unilateral bag, greater pressure occurs under the ipsilateral foot, generating changes in the distribution of plantar pressures.[23] From lateral loads, it is possible to verify a posterior displacement of the center of gravity, with an increase in total load discharge to the side where it is located.[23] A similar result was found in the present study, as it was noticed that the LMD shifted to the side where the bag was used in the evaluated women, being more significant for those who carried the bag on the right side.

Furthermore, from the moment that a greater incidence of pressure is observed on the ipsilateral side of the bag, it is possible to notice that the contact with the ground of the contralateral foot decreases.[29] In the present study, it was verified that the contact surface of the contralateral side opposite to the bag suffered a reduction, occurring mainly on the left side, which awakens the fact that carrying a load on the opposite side of the dominant one and alternating between the shoulders makes the bag become a balancing factor for an already pre-existing alteration.

Postural asymmetries related to hand preference are common. A previous study found that the shoulder on the preferred side tends to be lower than the contralateral side.[16] This has been associated with hypermobility of the soft tissue and stretching of ligaments and joint capsules due to more frequent use of the muscles.[16] This fact was also found in the present study, considering that the women who participated in the present research were mostly right-handed and had the left shoulder more elevated.

This asymmetry, however, can create an abnormal weight distribution on the lower extremities, causing the person to shift the center of gravity away from the base of support, changing the weight distribution on the lower limbs.[16] In this study, a reduction in the ipsilateral barycenter on the side of the bag was maintained. However, for women who carried the bag mainly on the left side and also alternated with the other side, the displacement of the center of gravity was insignificant.

Such changes in plantar pressures detected by baropodometry, caused by the imposition of an extra load added to the excesses to which women are exposed, cause a high prevalence of pain in this population, which can generate motor, psychological and social disorders.[30] Pain causes limitations that go beyond the physical aspect, also encompassing psychological and social aspects that sabotages daily activities, generating exhaustion.[1]

Thus, the result of this research shows the need for health promotion programs based on the logic of individual sense, in which the individual acquires knowledge and information, becoming capable of choosing options that do not compromise the optimal state of health.[31] Moreover, educational actions are recommended in health services aimed at the negative effects of using a unilateral bag on plantar pressures and static balance. Such knowledge favors the expansion of healthy choices by some of the women so that they take care of the maintenance and integrity of health.

Despite promoting the understanding of the theme, this study has some limitations, as the results obtained do not allow the understanding of causal relationships, due to the limitations of the cross-sectional design, in addition to being susceptible to memory bias. In addition, the use of the unilateral bag in different routine situations, such as leisure or at other times outside the work context, the use of different models and changes in the way of using it were not evaluated, not allowing a broader understanding of these interferences on the physical health of women. It is suggested that longitudinal studies are carried out to monitor changes related to the use of the unilateral bag.

## Conclusion

The use of the unilateral bag by women causes changes in plantar pressures and ipsilateral barycenter. It is also noteworthy that the results showed that the use of the bag on both sides minimizes these changes. On this perspective, the use of the bag is a risk factor or aggravation for dysfunctions of the musculoskeletal system and for the occurrence of pain, making educational actions necessary in the work environment and in health services.

## Authors' contribution

All authors were responsible for data collection, analysis and interpretation, conception and design of the study, revision of the manuscript, and approval of the final version.

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