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Use and weight of shoulder bag in female gait

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ORIGINAL ARTICLE

ABSTRACT

This work aimed to assess the influence of the use and weight of shoulder bag on female gait. A cross-sectional study was conducted from April to September 2018, with 258 women (18-59 years old) who used shoulder bags. A questionnaire was used, and body weight and bag weight were measured. Gait was assessed with and without a bag using a baropodometer. The percentage of bag weight-body weight ratio was associated with having children (OR=0.210, p=0.002) and doing physical activity (OR=2.122, p=0.049). As for the side used to carry the bag, right stride length increased when the bag was carried on the opposite site and decreased when carried on both sides (p<0.05). There was a reduction of the left surface area and left foot peak pressure, and an increase in the left step length in relation to the percentage of weight carried (p<0.05). Regardless of the side used to carry the bag and the weight of the bag, the changes perceived during gait while carrying shoulder bags were discrete. However, attention should be drawn to these changes, mainly due to the adaptive capacity of the body and the long-term effects of bag use.

Keywords: Gait; Weight-bearing; Woman; Risk Factors.

INTRODUCTION

Normal human gait can be defined as the gait humans use at low speeds to save energy. Walking is probably the most complex task performed by human beings as it involves, in addition to the lower limbs, several segments of the body that perform many movements in complex interactions in order to adapt and ensure adequate posture and hence enable a normal biomechanical gait pattern (Andrade, & Peyre-Tartaruga, 2015).

The interaction between several components – for instance, muscle strength, the timing of neuromuscular activation, and free joint mobility – is essential for adequate control of gait (Shiwa, Alouche, & Bagesteiro, 2015). In addition, the existence of problems in the structures involved, mainly in the muscles and lower limbs, is the main factor responsible for alterations in walking (Osawa, Shaffer, Shardell, Studenski, & Ferrucci, 2019).

Using different types of footwear (Metteling, Caldera, Geerons, Tours, & Cambier, 2015) and bags (An, Yoon, Yoo, & Kim, 2015), walking on uneven terrain (Wade, Redferm, Andrés, & Breloff, 2010), aging (Câmara, Zunzunnegui, Pirkle, Moreira, & Maciel, 2015), and overweight and pregnancy (Gottschall, Shuhan, & Downs, 2015) can alter the normal characteristics of biomechanical gait pattern and static posture in women.

The carriage of external loads, mainly in the transportation of loads and utensils, is part of everyday life. Accessories such as bags and backpacks were initially used to make such transportation easier. Women serve as a classic example of individuals who use bags as a practical and more common way of transporting personal and work-related items (Carrasco, 2010).

However, the extra load carried by women may cause changes in the compressive forces acting on the spine and lower limbs and shift the body centerline to maintain stability, thus leading

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to abnormal postural alignment and changes in gait patterns (Shiwa, Alouche, & Bagesteiro, 2015).

The functional assessment of these changes in women will explain the mechanisms of injuries from carrying extra loads. Bag weight and mode of carriage are believed to cause changes in step length and stride length and affect feet-ground contact time, thus affecting gait speed and cadence (Hyung, Lee, & Know, 2016). One of the functional tests used in this field is the baropodometry, an accurate method for early detection of dysfunctions that collects data on risk factors and identifies potential gait and plantar pressure injuries (Baumfeld et al., 2019)

In view of the observations outlined above, the present study aimed to assess the influence of the use and weight of shoulder bag on female gait.

METHOD

An analytical cross-sectional study was carried out at the University of Fortaleza (UNIFOR), located in the city of Fortaleza, Ceará, Brazil, from April to September 2018.

Fortaleza, the capital of the state of Ceará, is located on the Atlantic coast of Northeastern Brazil. It has a warm and subhumid tropical climate with average temperatures ranging from 26ºC to 28ºC. It is the fifth most populous capital in the country, with 2,452,185 inhabitants – 1,304,287 of whom are women (Brazilian Institute of Geography and Statistics [IBGE] 2013). The female population of Fortaleza represents 41.8% of the economically active population (Inter-union Department of Socioeconomic Statistics and Studies [DIESE] 2017) with a standard working week of 44 hours.

This study was approved by the Research Ethics Committee of the University of Fortaleza (Approval No. 2.234.844). All the participants were informed about the research objectives and procedures and gave their written informed consent.

Sample

The research population consisted of women aged 18 to 59 years who were selected irrespective of the type of work they performed. Women who used shoulder bags – regardless of the model – at the time of data collection were included. Women diagnosed with shoulder and/or spine injury and/or who used limb prostheses/orthoses were excluded. Women who carried bags weighing less than 1 kg were also excluded from the sample.

The sample size was estimated considering the population of women in the city of Fortaleza, Ceará, Brazil (n=1,304,287), a 20% prevalence rate of shoulder pain (Luz, Magnago, Greco, Ongaro, & Panes, 2017), a 5% precision and a 95% confidence interval. The final sample size was estimated to be 246 women.

Initially, 265 women participated in the study. However, seven women were excluded from the study because they did not participate in all data collection stages. Therefore, the final sample comprised of 258 women. Women who attended the institution on the days set for data collection were directly invited to participate or selected through recruiting posters published in the institution and social media.

Data collection procedures and study variables

The selected participants gave their written consent before data collection. Data were collected in a laboratory at two different stages. In the first stage, a questionnaire was used to collect demographic data (age, education, and children), life habits data (physical activity and sleep position), information on bag use (side used to carry the bag and duration of carriage in hours), and information on the presence of pain and its characteristics.

Pain intensity was assessed using the Visual Analog Scale (VAS), which consists of a 10-cm horizontal line anchored at the ends by the numbers 0 (no pain) and 10 (worst possible pain). Pain intensity was classified as mild (1-4), moderate (5-6), and severe (7-10) (Rosas, Paço, Lemos, & Pinha, 2017).

The symmetry of shoulder girdle (shoulder elevation) was assessed, and body weight and bag weight were measured. Assessment of scapular symmetry was performed using a standard shoulder palpation protocol (Santos, 2001).

A portable digital scale (Plenna®) with 150 kg capacity and 100 g sensitivity was used to measure body and bag weight. Bodyweight was measured with the participant standing barefoot over the center of the scale platform with weight evenly distributed between both feet, arms at sides, and head up (Thomaz, Silva, & Costa, 2003). Bag weight was measured by placing the bag and its content on the center of the scale platform.

In the second stage of data collection, the participants were submitted to gait assessment using a 2-meter electronic baropodometer (FootWork Pro, AM CUBE, France) with a 200-Hz sampling frequency coupled to a running track. The analyses were performed using Footwork Pro version 3.7.0.1 (*IST Informatique - Intelligence Service et Tecnique*, France).

The participants were asked to walk a distance of 12 meters (i.e., six laps on the track). Only the data obtained in the eight intermediate meters, which corresponded to the useful area of the baropodometer, were considered (Fortaleza et al., 2014). The assessments were performed with and without the bag with a 1-minute interval between the assessments.

Distance walked (cm), average speed (mm/s), step time (s), right (R) and left (L) foot surface area (cm^2), step duration (ms), step and stride length (cm), peak pressure (kPa), contact time (ms) and peak pressure location (forefoot, midfoot, hindfoot, hallux, and toes) for right and left feet were measured.

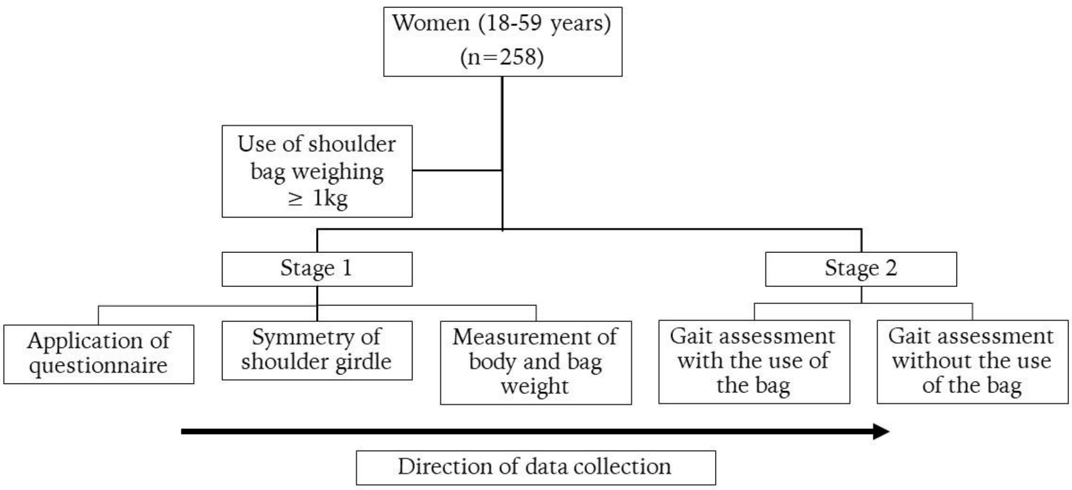

Figure 1. Data collection flow diagram.

Statistical analysis

Data were analyzed using descriptive and inferential statistics in SPSS version 23.0. Categorical variables were described using relative (%) and absolute (n) frequencies, and numerical variables were described using means and standard deviations of the mean.

Some variables were dichotomized for inferential analysis: categorized age (≤25 years and >25 years); education (≤8 years of education up to completed secondary school education and >8 years of education up to completed higher education); sleep position (lower joint pressure in a supine sleep position and higher joint pressure in lateral and prone sleep positions); duration of carriage in hours (≤2 and >2); and percentage of bag weight-body weight ratio (≤ 5% and> 5 %) calculated using the formula.

$$\%\text{bagweight} = \frac{\text{bag weight} \times 100}{\text{body weight}}$$

Bivariate analysis was performed to check for associations between the dependent variable (%bagweight) and associated factors using the chi-squared test followed by the calculation of crude odds ratio (OR) and their respective confidence intervals (CI). Subsequent multivariate regression analysis was performed with the associations that exhibited a significance level of up to 0.05 in the bivariate analysis. The final model consisted of a hierarchical factor model with estimates of adjusted OR and their respective confidence intervals (CI).

The influence of bag use and %bagweight on gait parameters was assessed using the t-test with a significance level of 5% after the Kolmogorov-Smirnov (KS) normality test.

Table 1

Bivariate analysis of the relationship between the percentage of bag weight-body weight ratio (%bagweight) and associated factors. Fortaleza, Ceará, 2018.

Associated factors	Percentage of bag weight-body weight ratio (%bagweight)		Crude OR (95%CI)	p-value#
	≤ 5	> 5		
Age (years)				
≤ 25 years	94 (43.9)	25 (56.8)	1	0.118
< 26 years	120 (56.1)	19 (43.2)	0.595 (0.309-1.146)	
Education				
≤ 8 years	38 (17.8)	4 (9.1)	1	0.156
> 8 years	176 (82.2)	40 (90.9)	2.159 (0.729-6.396)	
Children				
No	132 (61.7)	39 (88.6)	1	0.001*[a]
Yes	82 (38.3)	5 (11.4)	0.780 (0.078-0.545)	
Physical activity				
No	90 (42.1)	11 (25.0)	1	0.035*[b]
Yes	124 (57.9)	33 (75.0)	1.045 (1.045-4.538)	
Side used to carry the bag				
Right	121 (56.5)	22 (50.0)		
Left	49 (22.9)	12 (27.3)	-	0.719
Both	44 (20.6)	10 (22.7)		
Shoulder elevation				
No	145 (67.8)	25 (56.8)	1	0.163
Yes	69 (32.2)	19 (43.2)	1.597 (0.824-3.096)	
Sleep position				
Lower joint overload	25 (11.9)	4 (9.1)	1	0.285
Higher joint overload	185 (88.1)	40 (90.9)	1.351 (0.446-4.098)	
Pain				
No	94 (44.3)	15 (34.9)	1	0.256
Yes	118 (55.7)	28 (65.1)	1.487 (0.751-2.944)	
Duration of bag carriage (hours)				
≤ 2.0	139 (65.0)	24 (54.5)	1	0.192
> 2.0	75 (35.0)	20 (45.5)	1.544 (0.801-2.958)	

OR - Odds Ratio; 95%CI - 95% Confidence Interval; #Chi-squared test; *p<0.05; Effect size determined by the Phi Coefficient: [a]-0.214;[b]0.131.

RESULTS

There was a higher proportion of women aged 26-49 years (n=119; 46.1%), and most of the participants had not completed higher education (n=136; 52.7%). The majority of the participants had children (n=171, 66.3%). With regard to lifestyle habits, 60.9% (n=157) of the participants did physical activity, 87.2% (n=225) slept in a position that led to higher joint overload, and 56.6% (n=146) presented shoulder pain, with pain predominating on the right side (n=60, 23.3%). As for bag use, 55.4% (n=143) of the participants carried the bag on the right shoulder and for less than 2 hours (n=163; 63.2%).

The bivariate analysis showed that having children (OR=0.780, p=0.001) and doing physical activity (OR=1.045, p=0.035) influenced the percentage of weight carried by women (Table 1).

In the multivariate analysis, having children (OR=0.210, p=0.002) and doing physical activity (OR=2.122; p=0.049) remained associated with a higher percentage of weight carried by women (Table 2).

Table 2
Multivariate analysis of the relationship between the percentage of bag weight-body weight ratio (%bagweight) and associated factors. Fortaleza, Ceará, 2018.

Associated factors	Adjusted OR (95%CI)	p-value
Children	0.210 (0.079-0.556)	0.002*
Physical activity	2.122 (1.004-4.486)	0.049*

OR: odds ratio; 95%CI: 95% Confidence Interval. Parameters of the final model: 0.067 (Cox & Snell); 0.112 (Nagelkerke); χ^2 of the model = 17.956. *p<0.05.

A total of 56.6% (n=146) of the women presented shoulder pain. In all, 41.4% (n=60) of the participants reported right shoulder pain, 36.6% (n=53) reported pain in both shoulders and 22.1% (n=32) reported left shoulder pain. In addition, 51.9% (n=67) of the participants experienced pain up to three times a week, and 48.1% (n=62) experienced pain more than three times a week. With regard to pain intensity, 53.5% (n=77) of the participants reported moderate pain, 23.6% (n=34) reported severe pain and 22.9% (n=33) reported mild pain.

The gait assessment showed no significant changes in relation to the distance walked (cm) while carrying a bag regardless of the shoulder on which the bag was carried (p>0.05). There was a slight decrease in average speed (mm/s) in all the groups (R, L, and both shoulders) with the use of the bag, but the differences were not significant (p>0.05) (Table 3).

There were no significant changes in the R and L surface area (cm^2) when carrying the bag (p>0.05) (Table 3). However, there was an increase in peak pressure (kPa) in both feet and a reduction in feet-ground contact time (ms), but both changes were not significant (p>0.05) (Table 3).

The duration (ms) and length of R and L steps decreased in the groups when the bag was used, but the changes were not significant (p>0.05). The use of the bag did not cause significant changes (p>0.05) in step time (s). However, there was a slight reduction in step time in the women who carried the bag on the right shoulder and both shoulders (Table 3).

There was a significant increase in the length of the right stride after placing the bag on the left shoulder (p=0.01), and a decrease when the bag was carried on both shoulders (p=0.038). There were no significant changes in the length of the left stride (p>0.05) (Table 3).

The assessment of the impact of the weight carried by women on gait showed that the distance walked and the average speed slightly decreased in both groups (<5% and >5%) when a bag was carried, but the changes were not significant (p>0.05) (Table 4).

Surface area (p=0.033) and peak pressure (p=0.027) for the left foot reduced significantly when the bag was carried (Table 4). There was a slight increase in surface area and peak pressure for the right foot and a decrease in feet-ground contact time, but the changes were not significant (p>0.05) (Table 4).

There was a reduction in step duration and an increase in stride length when the bag was carried in both groups (<5% and> 5%), but the changes were not significant (p>0.05). There were no significant changes in step time (s) when the bag was carried (p>0.05). However, step time slightly reduced in women who carried a bag weighing less than 5% of body weight and increased in those carrying a bag weighing more than 5% of body weight (Table 4).

Left step length significantly increased when a bag was carried (p=0.013). There were no significant changes in right step length (p>0.05) (Table 4).

With regard to pressure location, 53.9% (n=139) and 53.5% (n=138) of the women exhibited pressure on the forefoot in both feet, with a slight increase in both feet when the bag was carried (n=141; 54.7) (Table 5).

Table 3
Gait parameters in relation to bag use characteristics in adult women. Fortaleza, Ceará, 2018.

Variables	Gait Assessment						p-value[a,b,c]
	Without the bag			With the bag			
	Side used to carry the bag#						
	right	Left	both	right	left	Both	
Distance walked (cm)	173.70 ± 16.93	174.46 ± 15.98	172.00 ± 18.57	171.78 ± 16.60	174.00 ± 16.80	174.27 ± 16.90	0.097-0.825-0.337
Average speed (mm/s)	309.35 ± 61.56	312.23 ± 64.27	301.85 ± 73.44	304.65 ± 50.59	302.53 ± 49.19	301.75 ± 74.79	0.272-0.222-0.999
R surface area (cm^2)	92.15 ± 22.04	90.65 ± 18.07	92.24 ± 13.14	94.48 ± 22.74	88.72 ± 14.52	90.78 ± 15.45	0.115-0.303-0.319
L surface area (cm^2)	91.07 ± 14.41	88.28 ± 16.25	90.99 ± 15.37	91.33 ± 15.61	89.93 ± 16.86	90.47 ± 15.86	0.754-0.253-0.796
R step duration (ms)	814.89 ± 396.21	765.24 ± 136.29	760.92 ± 101.33	793.91 ± 325.76	735.57 ± 116.06	756.11 ± 108.79	0.368- 0.116-0.715
L step duration (ms)	784.68 ± 298.73	804.09 ± 538.39	751.29 ± 111.94	752.02 ± 165.02	806.22 ± 422.21	743.51 ± 91.26	0.168-0.939-0.541
R step length (cm)	32.65 ± 14.53	31.59 ± 5.37	33.17 ± 14.58	30.86 ± 5.83	32.07 ± 4.32	30.94 ± 5.83	0.149-0.324-0.280
L step length (cm)	32.26 ± 13.55	33.56 ± 13.79	31.95 ± 5.87	31.64 ± 5.59	32.66 ± 5.79	31.72 ± 6.03	0.581-0.603-0.650
R stride length (cm)	104.65 ± 10.57	104.10 ± 11.88	109.17 ± 12.10	105.37 ± 11.02	108.27 ± 9.82	106.81 ± 12.98	0.237-0.011*[d]-0.038*[e]
L stride length (cm)	108.18 ± 11.07	108.88 ± 12.93	109.24 ± 12.26	108.37 ± 13.66	110.47 ± 9.85	107.79 ± 11.94	0.590-0.161-0.278
Step time (s)	2611.11± 931.10	2449.50±697.30	2431.85±568.42	2471.74±615.61	2452.45 ± 922.45	2366.29±558.96	0.065-0.960-0.368
R peak pressure (kPa)	308.27 ± 77.73	300.98 ± 71.97	290.68 ± 49.32	306.44 ± 82.75	317.49 ± 71.70	307.22 ± 81.14	0.822-0.132-0.200
L peak pressure (kPa)	305.76 ± 88.48	290.90 ± 52.57	296.66 ± 63.82	305.70 ± 73.81	305.62 ± 58.24	311.00 ± 86.64	0.944-0.084-0.281
R contact time (ms)	680.55 ± 231.85	642.13 ± 116.19	638.51 ± 88.53	654.19 ± 157.11	629.34 ±109.57	658.88 ± 182.55	0.171-0.407-0.379
L contact time (ms)	662.79 ± 229.87	675.47 ± 415.52	671.11 ± 224.79	645.87 ± 123.93	674.75 ± 250.02	641.59 ± 125.73	0.385-0.984-0.199

R: right, L: left. *$p<0.05$, statistically significant compared with the side on which the bag was carried. [a]bag was carried on the right side, [b] [a]bag was carried on the left side and [c] [a]bag was carried on both sides compared with the assessment without the bag. Effect size determined by Cohen's d: [d]-0.382, [e]0.188.

Table 4

Gait parameters in relation to the percentage of bag weight-body weight ratio (%bagweight) in adult women. Fortaleza, Ceará, 2018.

Variables	Gait Assessment				p-value[a,b]
	Without the bag		With the bag		
	%bagweight				
	≤ 5	> 5	≤ 5	> 5	
Distance walked (cm)	173.67 ± 16.92	172.89 ± 17.69	173.08 ± 16.48	171.59 ± 17.82	0.784 - 0.592
Average speed (mm/s)	308.51 ± 67.98	308.24 ± 45.93	303.29 ± 58.18	304.85 ± 65.07	0.980 - 0.867
R surface area (cm^2)	92.10 ± 20.01	90.45 ± 17.03	92.92 ± 20.81	89.55 ± 13.34	0.611 - 0.304
L surface area (cm^2)	91.30 ± 15.31	85.99 ± 13.01	91.14 ± 16.11	89.23 ± 14.96	0.033*[c] - 0.469
R step duration (ms)	798.36 ± 332.44	760.22 ± 110.86	780.18 ± 275.05	733.40 ± 104.87	0.453 - 0.268
L step duration (ms)	791.68 ± 377.69	736.99 ± 89.50	767.66 ± 262.70	740.68 ± 99.98	0.337 - 0.503
R step length (cm)	32.24 ± 12.36	33.85 ± 15.54	31.06 ± 5.56	31.67 ± 4.80	0.453 - 0.506
L step length (cm)	32.50 ± 13.38	32.50 ± 5.44	31.50 ± 5.62	33.84 ± 5.98	0.998 - 0.013*[d]
R stride length (cm)	104.89 ± 11.24	108.07 ± 10.46	106.19 ± 11.18	109.84 ± 10.34	0.127 - 0.082
L stride length (cm)	104.89 ± 11.24	108.07 ± 10.46	108.78 ± 12.79	111.31 ± 12.26	0.165 - 0.266
Step time (s)	2579.62 ± 871.64	2320.22 ± 402.62	2465.79 ± 730.87	2344.54 ± 419.14	0.055 - 0.288
R peak pressure (kPa)	304.07 ± 73.97	297.00 ± 57.64	309.78 ± 82.59	306.50 ± 65.07	0.550 - 0.804
L peak pressure (kPa)	302.32 ± 76.13	290.75 ± 78.39	311.34 ± 74.98	284.68 ± 59.59	0.362 - 0.027*[e]
R contact time (ms)	667.99 ± 201.21	636.81 ± 83.88	652.38 ± 162.01	634.31 ± 99.02	0.314 - 0.477
L contact time (ms)	675,29 ± 307,95	629,77 ± 79,86	652,45 ± 173,87	648,63 ± 93,07	0,332 - 0,888

R: right, L: left. *$p<0.05$, statistically significant compared with the percentage ≤ 5%. [a]gait without the bag and [b]gait with the bag. Effect size determined by Cohen's d: [c]0.373, [d]-0.403, [e]0.393.

Table 5

Distribution of women according to the characteristics of plantar pressure incidence. Fortaleza, Ceará, 2018.

Variables	Without the bag	With the bag
	n (%)	
Pressure location in R foot		
Forefoot	139 (53.9)	141 (54.7)
Midfoot	6 (2.3)	5 (1.9)
Hindfoot	35 (13.6)	42 (16.3)
Hallux	76 (29.5)	69 (26.7)
Toes	2 (0.8)	1 (0.4)
Pressure location in L foot		
Forefoot	138 (53.5)	141 (54.7)
Midfoot	2 (0.8)	3 (1.2)
Hindfoot	53 (20.5)	39 (15.1)
Hallux	65 (25.2)	74 (28.7)
Toes	0 (0.0)	1 (0.4)

DISCUSSION

In the present study, information on demographic characteristics, life habits, bag use characteristics, and pain were collected. The results revealed a higher proportion of women aged 26 to 59 years, and most of the participants had not completed higher education. Additionally, most of the participants had children, did physical activity, slept in an inadequate position, and reported pain.

The influence of the percentage of weight carried was reduced in women with children, which may be explained by the woman's need to reduce the weight of the bag due to the several items needed by the child. To the best of our knowledge, there are no studies to confirm or refute such hypothesis, and this assumption was made on the basis of what was observed in everyday life of the women analyzed.

In a previous study, individuals with more years of education exhibited a higher frequency of physical activity compared with those with less than 5 years of education (Avelas et al., 2016). The same was also observed in the present study, in which there was a predominance of women with more than 8 years of education who did physical activity.

Moreover, doing sports increased the percentage of weight carried. This finding suggests that active women may either perceive themselves as more tolerant to heavy loads or need to carry more physical activity-related items in their bag.

Indeed, physical activity increases effort tolerance. However, it should be noted that women are multi-taskers and hence need to carry many items to meet their needs (Tristane & Riom, 2015). Women's constant need to carry heavy bags due to the multiple tasks they need to perform leads to pain experience (Abdon et al., 2018). In the present study, most of the women experienced significantly intense shoulder pain on the side used to carry the bag.

In a previous study, many of the participants who used bags presented moderate nocturnal pain predominantly on the right side (Rodrigues, Montebelo, & Teodoro, 2008). This finding is consistent with the findings of the present study, as most of the women presented the same characteristics. Regarding bag use characteristics, a higher proportion of women carried bags weighing ≤ 5% of their body weight and on the right side.

The present study also analyzed the locations that received greater pressure with and without the bag. The forefoot was the location with the greatest pressure accumulation in both feet, regardless of whether the bag was carried. Researchers agree that carrying a weight of 10% of body weight on one side of the body can alter maximum pressure distribution on the opposite side and that these changes can also occur with loads of 5% of body weight, particularly in the hindfoot (Gong, Lee, & Kim, 2010). In contrast, the present study demonstrated a similar distribution of maximum pressure in the forefoot region in both feet regardless of the side on which the bag was carried, with most women carrying bags weighing ≤5% of their body weight.

However, there was a significant increase in maximum pressure in the left foot when women carried bags weighing more than 5% of their body weight, which agrees with the aforementioned study (Gong, Lee, & Kim, 2010). This finding is inconsistent with the results of studies that reported no difference in foot pressure between the left and right sides during gait regardless of the weight of the bag (Hyung, Lee, & Know, 2016; Abaraogu, Ugwa, Onwuka, & Orji, 2016; Carrasco, 2010).

Another study suggested that a bag should weigh no more than 10% of its carrier's weight as it has insignificant effects on the region used to carry the bag (hand or shoulder) and significant effects on the side used to carry the bag. This fact was not observed in the present study as it assessed only the use of shoulder bags and found no significant changes on the side used to carry the bag (Son & Noh, 2013).

When people walk while carrying a heavy bag on one side of the body, the foot on the same side has a larger ground reaction force than the opposite foot, thereby increasing asymmetry. Moreover, during walking, this foot requires larger muscular strength, propulsive force, and energy consumption (Abaraogu, Ugwa, Onwuka, & Orji, 2016; Son & Noh, 2013).

A study carried out with women found that step length, stride length, and step frequency changed significantly depending on the side of the body used to carry the bag and its weight (Hak, Houdijk, Mert, & Wurff, 2012). In the present study, discrete alterations were observed, but unlike the study mentioned above, they were not significant. Only the right stride length changed significantly in the women who carried the bag on the left side and both sides, thus contradicting the assumption that carrying the bag on one side leads to changes in gait.

Previous research has shown that walking while carrying a bag reduces average walking speed, but without significant changes, that is, carrying a bag while walking does not significantly impair speed (An, Yoon, Yoo, & Kim, 2010). This finding is in line with the findings of the present study, which showed that carrying a bag slightly reduced average speed, but without significant changes.

A recent study found that the methods of carrying a handbag in the hand or over the shoulder had no effects on gait velocity or other gait components (Son & Noh,2013). However, increases in bag weight have been found to shorten stride length and step length and increase the contact time of the weight-bearing foot (Hyung, Lee, & Know, 2016).

A similar study found that as the weight of the bag increases, the step width increases, and a mechanism to reduce the speed and cadence occurs to stabilize gait (Chow et al., 2005). Both findings differ from the findings of the present study as only step length, and left foot peak pressure were sensitive to increases in asymmetric load.

Individuals who carry bags on their right side have relatively larger step lengths and shorter step duration, whereas their step widths and gait angles are relatively smaller. Therefore, distance variables related to walking distance exhibit differences according to bag-carrying habits (Son & Noh, 2013). In the present study, there was a slight reduction in gait-related temporal variables according to the side used to carry the bag, but the changes were not significant.

A recent study found that unilaterally carrying a bag weighing more than 15% of body weight promotes changes in pelvic tilt. This finding is important because the pelvis is actively involved in the process of walking and hence directly influences gait kinetics and kinematics. In addition, right pelvic tilt significantly increased and pelvic rotation decreased when a shoulder bag was carried (Hyung, Lee, & Know, 2016).

When walking with an excessive unilateral load, the trunk is tilted and the centerline of gravity is moved into the basal plane so that the leftward or rightward pelvic tilt increases. Therefore, lateral weight shifts while walking are thought to increase, thus leading to increased energy consumption and unnecessary trunk movements (Hyung, Lee, & Know, 2016).

The weight, location, and method of carrying a bag cause the physical response of maintaining balance when the location of the weight line changes. Moreover, in moving forward, the body uses an adaptation mechanism in order to rearrange the body segments in an abnormal posture (Oh, & Choi, 2007). The adaptive process that occurs in the body when walking while carrying an asymmetric load may explain why practically none of the variables analyzed in the present study presented significant changes.

This finding is in agreement with a study that found that although several changes occur during a loaded walking task, the body presents the same characteristics of the unloaded condition after walking a certain distance, thus suggesting adaptation and tolerance to the weight and asymmetry (Fowler, Rodacki, & Rodacki, 2006).

The limitations of the present study are related to its cross-sectional design, which impeded the identification of potential causal factors that could have led to pre-existing alterations in the study sample. Moreover, the use of shoulder bags in leisure and work activities could not be assessed because there was no long-term follow-up to understand usual bag use behavior in the women analyzed.

In view of the observations outlined above, the results of the present study demonstrate the need to develop an action plan targeted at individual care based on the premise that the individual, as a knowledge holder, is capable of making choices that do not compromise their physical and emotional health. This study is expected to foster an understanding of the subject herein discussed; however, longitudinal studies should be carried out to monitor changes caused by the use of bags. Besides, other studies should assess the particularities of the use of shoulder bags in moments of leisure or outside the working environment.

CONCLUSION

Carrying shoulder bags, particularly on the right side and weighing more than 5% of the woman's body weight, caused changes in the fundamental components of gait, thus affecting the gait cycle, increasing overload on the forefoot and generating changes in the feet-ground contact area. Although these changes were discrete, they should be taken into account, especially because of the adaptive capacity of the body and the long-term effects of bag use.

This study focused on the female population and, therefore, it is important to emphasize the impossibility of analyzing bag use without taking into account external factors that are part of women's everyday life and that directly or indirectly influence bag weight and carriage mode in everyday life, such as physical activity and having children.

It should be noted that our study findings revealed that alternating the shoulder on which the bag is carried minimizes changes. Therefore, it is important to provide guidance and raise awareness of the risks posed by shoulder bag overload and misuse.

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