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EVALUATION OF THE EFFECT OF THE CARRIED BAGGAGE ON THE SELECTED STABILOMETRIC PARAMETERS, BODY POSTURE, AND OCCURRENCE OF PAIN IN YOUNG WOMEN

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Background: Posture ergonomics is becoming an increasingly discussed issue in the literature. The effect of daily habits and attitudes, especially overloading ones, is an important topic of currently conducted research. Performing simple tasks correctly is an important aspect. The following paper deals with the topic of women's handbags and the effect of carrying them on various stabilometric parameters.

Aim of the study: This study aimed to check whether the examined women who carry a one-shoulder bag are affected by posture and the occurrence of pain.

Material and methods: Forty-two women aged 20–25 years were enrolled in the study and were assigned to two equal comparison groups: group A – ladies carrying a purse on the right arm and group B – ladies carrying a purse on the left arm. The following tests were performed: evaluation of postural stability, including total sway path (SP) using a stabilometric platform, the degree of spinal curvature was assessed with a scoliometer, the degree of pelvic tilt was measured with an electronic inclinometer, and the extent of lateral head flexion was checked with an electronic goniometer. Back pain intensity was assessed using the VAS scale.

Results: There appeared to be a statistically significant difference in the transfer of the center of gravity to the right side in group A and to the left side in group B. As for the stabilometric parameters, only the SP [mm] parameter achieved statistical significance. The highest correlations were observed in group A, between pain complaints and the range of head flexion to the right ($r = -0.62$). In both groups, no significant statistical differences were found within the groups with and without declared pain ($p > 0.05$). However, in the intergroup comparison for patients without a bag ($p = 0.01$), with their own bag ($p = 0.04$), and with a 3 kg bag ($p = 0.02$), there were statistically significant differences.

Conclusions: A bag worn on one shoulder can provoke the occurrence of back pain. The stabilometric results indicate abnormalities while free-standing. Education about pain prevention and maintaining proper posture is important.

KEYWORDS: back load, carry-on luggage, back pain, body posture

Background

Posture ergonomics is becoming an increasingly discussed issue in the literature. This may be due to the ever-increasing number of people suffering from chronic pain associated with various medical conditions. Effect observations of individual elements of everyday life on human body functioning have become an important area of research [1].

Looking more closely at arthritis and reported pain, women should pay particular attention to adopting the correct posture on a daily basis and make sure they are not carrying unnecessary weight. When working, women report more pain than men. Neck and shoulder joint disorders are mentioned as the most common ones, next to the most popular lower spinal pain [2]. This emphasizes the need for changes in women's functioning and the use of prevention in this area.

In their studies, Dockrell et al. [3] and Korovessis et al. [4] indicated that spinal pain affects adolescent females more often than adolescent males. This may be related to the decrease in upper body muscle strength of females [5]. The typical method of carrying bags in adolescent girls is to put them on one shoulder and wear them on the same side of the body [6]. This method of bag carrying can negatively affect posture and provoke pain [7].

In available search engines (Web of Science Core Collection, PubMed, MEDLINE), we found a limited number of published studies on the impact of carrying luggage on spinal load, pain, and body posture in young women.

Toledo et al. studied 258 women carrying a bag on one shoulder. In their research, women had their static balance assessed using a two-meter electronic baropodometer (FootWalk Pro, AM CUBE, France) with a sampling frequency of 200 Hz. It has been shown that the use of a unilateral bag by women causes changes in plantar pressure and the ipsilateral center of gravity. It is a risk factor or an intensification for musculoskeletal dysfunction and pain [8].

Polish researchers conducted research aimed at determining changes in body posture depending on the way a light handbag is carried. Thirty-two young people (20 women and 12 men) took part in the project. Participants underwent body posture testing using the ZEBRIS Pointer system. In their report, the authors indicated that carrying even a small load in the form of a handbag can significantly change the quality of body posture and depend on the way the weight is transferred [9].

An important aspect may be education in the field of pain prevention and maintaining proper posture, as well as the implementation of the principles of luggage ergonomics as an element of pain prevention in school-age children.

In their paper, Hong et al. presented the relationship between spinal curvatures and their changes depending on the type of luggage and percentage of load. Thirteen boys walked up and down the stairs with a backpack symmetrically placed on their shoulders or with a bag placed diagonally on their left shoulder. The spinal range of motion was examined using a motion analysis system. Statistical significance was obtained for differences in spinal excursions with the bag worn over the shoulder. The excursions became larger as the bag's weight increased, 0%, 10%, 15%, and 20%, respectively. The largest differences were shown with loads exceeding 15%. For the tests with a backpack, and thus a symmetrical load, the excursions were not significant, regardless of its weight [10].

Different results were presented by Akbar et al. After examining approximately 950 children and the relationship between bag weights and lower spinal pain, no relationship was noted. Their observations suggest that the overall weight of the bag does not significantly affect the development of discomfort. In the study, the subjective attitude of the student wearing the backpack in relation to their complaints proved to be the most significant. If the student perceived that the baggage was heavy or very heavy, the likelihood of symptoms increased significantly. These researchers emphasized that lower back pain is generally prevalent and a characteristic of highly developed countries. The problem can occur as early as school age [11].

It is worth striving to eliminate factors that cause incorrect body positioning and the occurrence of pain. One of the elements may be the way of carrying a bag.

Aim of the study

This study aimed to check whether the examined women who carry a one-shoulder bag are affected by posture, stabilometric parameters, and the occurrence of back pain.

Material and methods

Study design

The study was conducted on a group of 42 women between the age range of 20 to 25 years carrying a handbag. The subjects were divided into two groups: women wearing handbags on the right side and women wearing handbags on the left side. The study was conducted in April 2020 in the functional testing laboratory at the Public Higher Medical Professional School in Opole, Poland.

Participants

Forty-two subjects were enrolled in the study, out of whom, the group of women wearing the purse on the right side constituted 21 subjects (50%), similar to the left side group, which also included 21 subjects (50%). The groups were homogeneous with respect to sex, age, body weight, and height. Pain complaints such as cervical, thoracic, and shoulder complex pain were present in 19 (45.23%) patients. The average bag weight was 2.5 kg. In contrast, the mean percentage ratio of bag weight to subject weight was 4.06±1.68%. Detailed data is shown in Table 1.

Table 1. Characteristics of the study group

Variables		Study group	Group A (Right) n=21	Group B (Left) n=21	p
Amount of patients	Women (n%)	42 (100%)	21 (100%)	21 (100%)	—
Age (years): Arithmetic mean Standard deviation Median Range		 22.0 1.62 22.0 20–25	 21.8 1.4 22.0 20–24	 22.1 1.9 23.0 20–25	0.55*
Height (cm): Arithmetic mean Standard deviation Median Range		 166.0 5.4 165.0 158–180	 166.0 4.1 165.0 159–178	 166.0 6.6 165.0 158–180	0.79*
Weight (kg): Arithmetic mean Standard deviation Median Range		 62.8 10.6 60.0 43–93	 62.6 9.6 60.0 49–87	 63.1 11.7 60.0 43–93	0.87*
BMI: Arithmetic mean Standard deviation Median Range		 22.8 3.6 22.1 17–32	 22.8 3.4 22.0 17–32	 22.8 3.9 22.2 17–31	0.95*
>30 (n%) <30 (n%)		2 (4.76%) 40 (95.24%)			—
Upper limb dominant:	Left (n%)	5 (11.9%)	2 (9.5%)	3 (14.3%)	0.63**
	Right (n%)	37 (88.1%)	19 (80.5%)	18 (85.7%)	
Lower limb dominant:	Left (n%)	4 (9.52%)	1 (4.24%)	3 (14.29%)	0.29**
	Right (n%)	38 (90.48%)	20 (95.24%)	18 (85.71%)	
Occurrence of ailments of pain	Occurrence of ailments (n%)	19 (45.23%)	7 (33.33%)	12 (57.14%)	0.12**
	No ailments (n%)	23 (54.77%)	14 (66.67%)	9 (42.86%)	
Weight of handbag (kg): Arithmetic mean Standard deviation Median Range		 2.5 0.9 2.45 0.49–4.56	 2.5 0.9 2.4 0.49–4.23	 2.6 0.9 2.5 0.78–4.56	0.72*
Distribution of % handbag weight to body weight of subjects [%]: Arithmetic mean Standard deviation Median Range		 4.1 1.7 4.1 0.8–8.3	 4.0 1.7 4.0 0.8–7.3	 4.2 1.7 4.2 1.4–8.3	0.90*

* U-Mann-Whitney test; ** χ^2 test.

Inclusion criteria

Inclusion criteria included consent to participate in the study and general good health, no injuries, or past surgeries within the previous year, age range of 20–25 years, and regularly carrying a single shoulder bag for at least 2 years.

Exclusion criteria

The criteria for exclusion from the research included refusal to participate in the research.

Ethical considerations

Prior to participation in the study, each participant was informed of the purpose and conduct of the study and gave informed consent. Each subject was instructed on the order of testing and given full instructions on how to perform the tests. The study was conducted in accordance with the Declaration of Helsinki. Approval was also obtained from the Institutional Review Board of the National Medical University of Opole, Poland (No. KB/200/FI/2019).

Data sources/measurement

The CQ Stab2P stabilometric platform (CQ Elektronik System, Czernica, Poland) was used to analyze postural stability parameters, including total path length (SP – Sway Path). The measurements were performed sequentially in three trials: in a free-standing position, with the subject's bag attached to the shoulder, and with a 3 kg fixed-weight bag attached to the shoulder. A single test lasted 30 seconds.

A K-FORCE electronic goniometer was used to measure the range of right and left lateral head flexion. The results were recorded according to the SFTR method. The standard, according to ISOM, is expressed in degrees Fahrenheit 45-0-45 [12].

Trunk asymmetry was measured using a Bunell scoliometer. The examination was performed in a standing position. The patient, positioned with her back to the examiner, performed a forward bend with her hands joined in front of her. The measurement was read at Th_1-$L_{5,}$ and the highest score was obtained and recorded.

The study also evaluated the degree of pelvic tilt using an OPIW Bevel Box electronic inclinometer. The measurement was made by applying the arms of a caliper to which the inclinometer is attached on the same side as the anterior superior iliac spine and the posterior superior iliac spine. The measurement was performed analogously on the left and right wing of the ilium.

Subjective pain sensations in the back area were determined using a visual analog scale (VAS, the pain intensity from 0 to 10; 0 means "no pain" and 10 means "the strongest pain").

Statistical methods

Statistical analyses were developed using the statistical package, Statistica version 13. Scale scores depending on whether the subjects had a bag or not and what bag it was were compared using the analysis for repeated measures Friedmann Annova test and post hoc Dunn Bonferroni test. The Mann-Whitney U test was used for comparisons between the two groups. Using the Spearman Rank Correlation Coefficient (r), it was checked whether there was a correlation between the degree of iliac wing tilt and the degree of back curvature (Table 6), the percentage distribution of body weight to the right or left side, the degree of pelvic tilt (Table 7), pain complaints, and the range of motion of lateral head flexion (Table 8). The correlation was greater the closer the value was to 1.0. Correlations between 0.2 and 0.4 were considered clear, 0.4 and 0.6 were considered significant, 0.6 and 0.8 were considered considerable, 0.8 and 0.9 were considered very high, whereas 0.9 and 1.0 were considered to mean virtually a complete correlation. A correlation below 0.2 was not significant. When a "–" appears in the result, it means that the relationship is inversely proportional. A test probability of $p<0.05$ was considered significant, and a test probability of $p<0.01$ was considered highly significant.

Results

During free standing on the stabilometric platform, before putting on the bags, regardless of the preferred side of carrying the luggage, the weight of the body rested more on the right side (for ladies preferring the right side – 51.3%, for ladies preferring the left side – 52.57%). A summary of the results is shown in Table 2. Comparisons were made between subjects wearing the bags on the same arm.

Table 2. Distribution of % body weight to the right side in the group of subjects carrying a handbag

Variables		Without a handbag (WH)	With an own handbag (OH)	With a 3 kg handbag (3H)	p*	Post-hoc
Group A	Mean±SD	51.3±2.8	53.3±4.5	55.1±3.8	<0.01	WH vs 3H
	Median (min-max)	51.0 (46.0–58.0)	54.0 (44.0–61.0)	55.0 (47.0–64.0)		
Group B	Mean±SD	52.6±3.8	48.5±3.1	48.8±4.1	<0.01	WH vs OH, 3H
	Median (min-max)	52.0 (47.0–63.0)	48.0 (42.0–56.0)	49.0 (39.0–57.0)		
p**		0.24	<0.01	<0.01		

p* – Friedmann Annova test; p** – U Mann-Withney test.

In group A – ladies carrying a bag on the right shoulder, there was a statistically significant (p<0.05) difference in terms of weight transfer to the side identical to the bag carried when the measurement values were compared without the bag on and with their own bag (p=0.043), as well as with their own bag and a 3 kg bag (p=0.021). Comparison between the results collected during the test without the bag and with a 3 kg bag yielded high (p<0.01) statistical significance (p=0.000). During testing, the subject's body weight was shifted to the right side.

In group B – ladies carrying a purse on the left arm, highly statistically significant (p<0.01) differences were found between measurements without and with their own purse (p=0.000), as well as without and with a 3 kg purse (p=0.002). There were no differences in the comparison of parameters with their own bags, compared to a 3 kg bag. The body weight of the subjects in this group shifted to the left side after putting on their luggage.

Table 3 shows the results of the percentage distribution of body weight on the right side depending on declared pain.

Table 3. Distribution of % body weight to the right side in the group of patients with different categories of pain

Variables		Without a handbag	With an own handbag	With a 3 kg handbag	p*	Post-hoc
With pain (19)	Mean±SD	50.3±2.4	49.5±4.7	50.5±5.4	0.26	—
	Median (min-max)	50.0 (47.0–56.0)	49.0 (42.0–61.0)	50.0 (42.0–64.0)		
Without pain (23)	Mean±SD	53.1±3.7	52.1±4.1	53.1±4.6	0.15	—
	Median (min-max)	53.0 (46.0–63.0)	53.0 (46.0–59.0)	54.0 (39.0–59.0)		
p**		0.01	0.04	0.02		

p* – Friedmann Annova test; p** – U Mann-Withney test.

In both groups, there were no significant statistical differences within the groups with and without declared pain (p > 0.05). However, in the intergroup comparisons of patients without a bag (p=0.01), with their own bag (p=0.04), and with a 3 kg bag (p=0.02), there were statistically significant differences. Patients without a reported level of pain showed greater deviation to the right, both without a bag (50.3±2.4 vs. 53.1±3.7), with their own bag (49.5±4.7 vs. 52.1±4.1), and with a 3 kg bag (50.5±5.4 vs. 53.1±4.6). This may be due to the fact that patients with declared pain compensated for the pain by stiffening their postural muscles, and therefore the right-side tilt was minimal, or they leaned to the left.

The results of the total SP in both groups are shown in Table 4.

Table 4. Mean statokinesiogram length as a function of carried baggage (SP [mm])

Variables		Without a handbag	With an own handbag	With a 3 kg handbag	p*	Post-hoc
Group A	Mean±SD	239.6±49.4	234.0±54.9	233.1±52.7	0.81	—
	Median (min-max)	234.0 (177.0–377.0)	220.0 (165.0–357.0)	219.0 (177.0–347.0)		
Group B	Mean±SD	216.7±38.6	210.1±32.4	207.6±36.5	0.10	—
	Median (min-max)	218.0 (143.0–286.0)	208.0 (142.0–277.0)	202.0 (146.0–309.0)		
p**		0.18	0.27	0.17		

p* – Friedmann Annova test; p** – U Mann-Withney test.

By analyzing the arithmetic averages, it can be seen that the path determined by the projection of the center of gravity in both groups shortens when luggage is added. This may suggest that adopting a more stable posture is performed to maintain balance, despite the asymmetrical load. In group A, the differences between the values without and with a 3 kg bag (p=0.000), as well as their own and a 3 kg bag (p=0.016), turned out to be statistically significant. In group B, the comparison of the results without a bag and with their own bag (p=0.000), as well as with a 3 kg bag (p=0.006), turned out to be highly statistically significant.

A summary of the arithmetic means of the measurements of lateral head flexion range, degree of spinal curvature, and degree of iliac wing tilt depending on the group is shown in Table 5.

Table 5. Summary of the arithmetic means of the range of right and left head flexion, right- and left-sided Cobb angle, and the tilt degree of the right and left iliac wings

Variables		Group A	Group B	p*
Range of right and left head flexion [°]	Right	35.43	32.86	0.16
	Left	33.9	31.38	0.26
Right and left-sided Cobb angle [°]	Right	4.37	1.98	0.96
	Left	1.81	0.81	0.71
Tilt degree of the right and left hip wings of ilium [°]	Right	9.66	10.61	0.37
	Left	8.47	9.75	0.31

Regardless of the preferred carrying side, the extent of right head flexion and the degree of right iliac wing tilt are greater than that on the left side. The same applies to back pain curvature, but the angle is greater in ladies carrying a purse on the right shoulder compared to the other group.

Table 6. Results of the correlation between the extent of iliac wing tilt and the right- and left-sided Cobb angle tests in groups A and B

Variables	Tilt degree of the right hip wing of ilium	Tilt degree of the left hip wing of ilium
Group A r-Spearmana correlation		
Curvature of thoracic spine on the right side	–0.25	0.03
Curvature of thoracic spine on the left side	0.39	0.36
Group B r-Spearmana correlation		
Curvature of thoracic spine on the right side	0.32	0.24
Curvature of thoracic spine on the left side	–0.08	–0.00

When comparing the degree of curvature of the spine and the tilt of the iliac wings, the highest correlations were shown in group A between the angle of tilt of the right iliac wing and the curvature of the spine on the left side (0.39), and in group B between the tilt of the right iliac wing and the curvature of the spine on the right side (0.32).

Table 7. Results of the correlation between the percentage distribution of body weight to the right or left side and the degree of tilt of the iliac wings in groups A and B

Variables	% distribution of body weight to the right side	% distribution of body weight to the left side
Group A r-Spearmana correlation		
Tilt degree of the right hip wing of ilium	0.13	–0.13
Tilt degree of the left hip wing of ilium	–0.10	0.10
Group B r-Spearmana correlation		
Tilt degree of the right hip wing of ilium	–0.26	0.26
Tilt degree of the left hip wing of ilium	–0.19	0.19

There was no correlation in group A between the percentage load of the right or left KD and the degree of right or left iliac wing tilt. A clear relationship (-0.26/0.26) was shown between the degree of right iliac wing tilt and the percentage distribution of body weight between the right and left sides.

Table 8. Results of correlation between the range of lateral head flexion and perceived pain in groups A and B

Group A r-Spearmana correlation	Range of right head flexion	Range of left head flexion
VAS Scale	–0.62	0.13
Group B r-Spearmana correlation	**Range of right head flexion**	**Range of left head flexion**
VAS Scale	–0.02	–0.02

When comparing pain complaints with the lateral head flexion range of motion in group A, there was a significant degree of negative correlation (–0.62) between the range of head flexion to the right and the subjects' complaints of pain. In practice, this may mean that the greater the subject's range of lateral head flexion to the right, the less pain they experience. No correlation was shown in group B.

Discussion

This paper addresses a topic that affects thousands of women around the world every day – can the daily carried handbag negatively affect our health? An important aspect of our study is the weight of the bag and the style of carrying it. The target group of our study was exclusively women, who use this type of luggage on a daily basis. Our study has shown that the way one carries the bag can affect pain perception and body posture.

Abdon et al. conducted a study on a group of 316 women. They showed a significant relationship between the weight of the bag worn and pain complaints in the subjects. There appeared to be a statistically significant relationship between the occurrence of pain and a bag heavier than 4% of its owner's body weight, which increased with the weight of the bag [13]. In our study, the average bag weight of women with pain was 4.11% of their body weight (with the average bag weight of all participants constituting 2.5% of their body weight).

The results developed by Li et al. suggest that the use of a properly controlled asymmetrical load may have an effect on reducing lateral spinal curvature. The weight used in their study constituted: 0%, 2.5%, 5%, 7.5%, 10%, and 12.5% of the participant's body weight. Cobb's angle decreased when the bag was placed on the side of the frame where the curvature was present (the weight was on the opposite side). This relationship occurred bilaterally [14]. In our study, the angle of spinal curvature was measured only in the free position, without loads. The results showed that individuals wearing a bag on the right shoulder on a daily basis had a higher average Cobb angle for right-sided curvatures (4.37°) compared to those wearing a bag on the opposite shoulder (1.98°). The situation is similar for left-sided curvatures.

According to Otrębska et al., the way a load is carried has a significant impact on the activity of individual muscles. The authors of their study demonstrated that asymmetrical loads can have an adverse effect on the human body, especially when performing everyday activities such as carrying a bag on one's shoulder and a handbag on the forearm. The study indicated that the quadriceps muscle was more active on the loaded side, while the latissimus dorsi muscle, the erector spinae muscle, and the gluteus medius muscle showed increased activity on the side opposite the load in most subjects. The erector spinae muscle is responsible for maintaining the balance of the torso [15]. Its highest activity was observed when carrying a bag on one shoulder, as indicated in the study by Hardie R et al. [7]. As stated in the study by Grimmer et al., in such situations, the center of gravity is pushed furthest to the side, which may cause a greater tendency for the spinal column to lean laterally [16].

In our study, patients with declared pain compensated for the pain they felt by stiffening their postural muscles, and therefore, their right-side tilt was minimal, or they leaned to the left.

Carrying various types of hand luggage asymmetrically may adversely affect body posture and provoke pain. As studies show, asymmetrically bearing loads can have an adverse effect on the human body [17,18]. Nevertheless, according to a study conducted by Pascoe et al., the vast majority of students (72.3%) choose to carry their bags on a single shoulder [19].

In their study, Hardie et al. suggested that a two-strap backpack should be used to carry loads to reduce spinal muscle activity, which in turn may reduce reports of back pain [7].

Other researchers have also reported that asymmetrical carrying in children and adolescents is a risk factor for back pain, and, as a result, may influence the occurrence of spinal pain in adulthood [20,21].

Limitations of the study

When analyzing the results of our study, it should be noted that the paper contains several limitations. It is certainly worthwhile to expand future studies by adding more precise measurement tools (e.g., superficial electromyography, 3D gait assessment). The small number of participants and their young age also constitute study limitations. The study design should be continued with more participants, as well as other age groups. The study also did not include information on the physical activity of the respondents, which affects functioning in daily life. These comments certainly represent the limitations of our publication. There is still a need to have other research centers continue their studies in the future and verify the results obtained. There is little literature available on the research presented in our paper.

Clinical implications

There is little research on the effects of handbag carrying on posture and the incidence of back pain in women. The study's findings discussed in our paper confirm the importance of this issue. It is important to continually educate people about prevention, to reduce the risk of back pain in people of all ages from carrying bags over one shoulder. One should avoid carrying the bag asymmetrically, especially in cases of people who have experienced pain. Carrying a backpack and evenly distributing the weight can be a safe alternative. In addition, shifting the bag regularly from one side to the other can have a positive impact on one's health.

Conclusions

After analyzing the results of our study, we conclude that the way women carry their handbags, taking into account their weight, has a significant effect on their posture, range of motion, and back pain. The method of carrying luggage and its weight can cause negative health effects. Education about pain prevention and maintaining proper posture is important. It is reasonable to implement the principles of luggage ergonomics as an element of pain prevention as early as in school-aged children.

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