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## Unilateral Shoulder Bags: Can They Be Worn in a Way to Reduce Postural Asymmetry?

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### ABSTRACT

**Purpose:** To investigate whether there is a way to wear a unilateral strap shoulder bag that will allow more symmetrical postural alignment, preventing potentially harmful musculoskeletal effects. **Subjects:** Sixty-five college student volunteers. **Methods:** Each participant donned a unilateral strap shoulder bag two different ways on the dominant and non-dominant shoulder while standing on a Postural Scale Analyzer to measure lower extremity weight distribution. **Results:** A significant improvement ( $p < 0.05$ ) in lower extremity weight distribution was found in right hand dominant subjects ( $n = 63$ ) when wearing a shoulder bag draped across the left shoulder to right hip. **Discussion:** When individuals who are right hand dominant wear a shoulder bag draped across the left shoulder (non-dominant shoulder), the weight distribution through the person's lower extremities becomes more equal indicating improved postural symmetry in static standing. **Conclusion:** It is possible that individual prescription of a unilateral bag on the non-dominant shoulder draped across the body can be utilized to create a reduction in postural asymmetry demonstrated by more evenly distributed lower extremity loading. **Recommendations:** Health care providers, parents, students, and educators should be educated to carry an across-the-body unilateral strap shoulder bag that reduces postural asymmetry and the risk of future development of biomechanical problems and back pain in adulthood.

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### INTRODUCTION

Carrying of a shoulder bag for prolonged periods of time can have negative effects on the human body.<sup>1,2</sup> These effects include musculoskeletal misalignment, muscle spasms, and postural asymmetry.<sup>1,2</sup> Repetitive periods of postural asymmetry can lead to asymmetric muscular activity which may contribute to the development of back pain over time.<sup>1</sup> Despite the warnings about harmful musculoskeletal effects of carrying shoulder bags, students continue to use shoulder bags because of convenience and the need to get needed items to class while moving freely throughout the day. This study investigated whether there is a way to wear a unilateral strap shoulder bag that reduces postural asymmetry.

### Literature Review

It has been reported that more than 90% of school children in developed countries carry some type of shoulder bag.<sup>3</sup> A study by Korovessis et al surveyed 695 high school students and found that 55% carried their shoulder bags asymmetrically.<sup>4</sup> According to the literature, there are a number of students of all ages who prefer to carry one-strap shoulder bags, and the majority of reports indicate that loads carried by students are greater than the recommended limits.<sup>5</sup> The position of a shoulder bag's strap whether draped across the body (right shoulder to left hip or vice versa) or single sided shoulder carriage (right shoulder to right hip or vice versa) may lead to different musculoskeletal compensations and postural asymmetries.<sup>1</sup>

According to the World Health Organization (WHO), low back pain will affect 80% to 85% of people over their lifetime.<sup>6</sup> The total cost of low back pain in the United States exceeds \$100 billion dollars per year.<sup>7</sup> Grimmer et al has indicated that 10% to 30% of teenagers experience back pain, especially lower back pain.<sup>2</sup> While wearing heavy shoulder bags may not be the primary cause of back pain, the use of a shoulder bag that is a significant weight in comparison to an individual's body mass is a risk factor for the development of low back pain.<sup>8,9</sup> If addressing the way school bags are carried can limit back pain in teenagers and young adults, it would be beneficial not only for the individual themselves, but also to reduce health care costs via preventative measures.

Carrying a shoulder bag throughout the duration of high school and college years has been shown to lead to back pain. The American Physical Therapy Association (APTA) suggests that "backpacks weigh no more than 15% of the carrier's total body weight."<sup>10</sup> Several studies also concur that an acceptable range of weight for bag carriage is between 10% to 15% of the individual's body weight.<sup>1,5,11-13</sup> Carrying a shoulder bag weighing more than 15% to 20% of body weight is associated with back pain, and improper use can result in changes in posture and gait.<sup>14</sup> Researchers from the University of California, San Diego stated that limitations in shoulder bag weights may reduce the number of national emergency room admissions per year (approximately 7,500) related to shoulder bag injuries.<sup>17</sup>

Heuscher et al found that low back pain is a common problem in fifteen to sixteen year olds, with 24% in this age group reporting limitations of daily activities or the need to seek health care measures secondary to pain.<sup>9</sup> This illustrates the importance that proper shoulder bag use be emphasized during the years of the highest growth rate, as it can be inferred that the susceptibility for injuries and permanent postural abnormalities are more likely to occur during this period.<sup>5</sup> The growth of the appendicular skeletal system ceases at sixteen years of age in females and eighteen years of age in males.<sup>15</sup> However, secondary ossification of the vertebrae is not complete until the mid-twenties.<sup>5</sup> Therefore, the spine may also be susceptible to injury throughout the college and post graduate years. A study by Smith et al suggests that long term shoulder bag carriage could cause permanent postural deviation in female college students due to altered pelvic rotation during gait.<sup>16</sup> This further supports that proper wear of a shoulder bag is important during formative skeletal stages when progressing from adolescence to adulthood.

In a study by Haselgrove et al, it was found that almost 50% of all students surveyed carried their shoulder bags for more than thirty-minutes per day.<sup>18</sup> Over time, carrying an overloaded shoulder bag for long periods is associated with the development of low back pain in adolescents.<sup>3</sup> Backpacks, like shoulder bags, have also been found to be detrimental to postural mechanics. Students wearing backpacks had back complaints more often than children with other types of bags.<sup>19</sup> Chow et al found that significant postural alterations were observed when backpack loads were at 15% of body weight.<sup>13</sup> The results also identified that when the load placement was at the level of the T12 vertebra, the least amount of postural deviation was observed compared with other levels, both superior and inferior.<sup>13</sup> Grimmer et al found that regardless of pack weight, a more superior carriage of a backpack leads to anterior postural changes such as forward displacement of the trunk compared with unilateral strap shoulder bags where the postural deviations were lateral deviations such as trunk sidebending.<sup>2</sup> Regardless of backpack carrying position, even if it is at the optimal level of T12 as indicated by Chow et al, there will always be some degree of musculoskeletal compensation or altered loading through joints and muscle group activation.<sup>13</sup> The goal however, is to identify the best position to minimize the negative postural impact over time, supporting the need for our study.

A study by Motman et al suggested that during shoulder bag carriage, asymmetry in muscle activity may indicate an inability to stabilize the trunk and contribute to development of back pain.<sup>1</sup> Asymmetrical activity in back musculature was observed via electromyography (EMG) while carrying a shoulder bag with the weight on the right side of the body (right shoulder to right hip).<sup>1</sup> Physical stress in the sagittal plane is found more with backpacks than single strap shoulder bag loading, although backpacks worn on both shoulders are thought to improve symmetry.<sup>1</sup> Some studies, however, have found that backpacks centered in between the shoulder blades cause the body to lean forward. This position results in backpack compensation displacing the upper body anteriorly over the lower body.<sup>2,4,11,20-23</sup>

Another factor that may aggravate or cause musculoskeletal problems resulting from shoulder bags is uneven weight distribution throughout the lower extremities, which is the basis for this study. Goh et al found that the disproportionate forces placed through the lumbar spine while carrying a shoulder bag are transferred disproportionately to the lower extremities.<sup>12</sup> Anatomical or physiological leg length differences also will distribute a disproportionate force, with more weight dealt to the shorter leg.<sup>24</sup> Similarly, carrying a unilateral strap shoulder bag may contribute to postural asymmetry and result in more weight being distributed through one lower extremity versus the other.<sup>11</sup> While there is no correlation between increased loading through a joint and pain, increased weight bearing/loading is associated with the development of joint arthrides.<sup>25-27</sup>

Studies have also shown that lateral spinal deviation can occur from carrying nearly any form of bag, as long as the weight of that bag is significant relative to that person's total body weight. Carrying a one strap shoulder bag or a bag with bilateral straps all contribute to spinal deviation.<sup>11,16</sup> Single strap support (right shoulder to right hip or vice versa) causes postural deviation consisting of ipsilateral shoulder elevation, contralateral sidebending away from shoulder bag, and pelvic obliquity.<sup>4,11,16,21,28</sup>

It is common to see postural asymmetries related to hand dominance.<sup>29,30</sup> Previous studies have found that the dominant shoulder is lower in position than the non-dominant shoulder. This has been associated with a hypermobility of the soft tissue and stretching of the ligaments and capsules of joints from more frequent use of the dominant musculature.<sup>29,30</sup> These asymmetries related to hand dominance are encountered commonly with no known correlation to race, gender, or somatotype. They also may be asymptomatic.<sup>29,30</sup> This asymmetry, however, could create an abnormal distribution of weight through the lower extremities. If a student wears a shoulder bag on the shoulder that is lower, this may create further asymmetries to posture and move the center of gravity outside of the base of support altering weight bearing distribution through the lower extremities. The purpose of this study was to investigate if there is a way to carry a shoulder bag so that the forces placed through the lower extremities become more equally distributed, thereby reducing postural asymmetry. In turn, this could potentially assist shoulder bag wearers and those that could provide appropriate instruction to wearers to promote optimal positioning of a shoulder bag thereby reducing potential postural asymmetry and musculoskeletal problems.

Based on a review of the literature, carrying a backpack or shoulder bag can cause uneven weight distribution through the lower extremities, postural asymmetry, musculoskeletal misalignment, and muscle spasms. This study specifically looked at unilateral shoulder bags. It was hypothesized that individuals could wear a shoulder bag in a more effective way to provide improved, centrally distributed forces that would equalize weight bearing through the lower extremities. It was hypothesized that students carrying a shoulder bag draped across the shoulder opposite to their dominant hand (the non-dominant shoulder, more superiorly situated shoulder) would equalize posture and create a more even weight distribution through the lower extremities.

## **METHODS**

### **Subjects**

Sixty-five female and male college students volunteered to participate in the study. The participants signed an informed consent document which was approved by the Florida International University institutional review board. Participants were excluded if they had experienced trauma, injury, or pain to any lower or upper extremity joint in the previous six months, general musculoskeletal trauma (including low back trauma) over the previous three months, or who had a leg length discrepancy of more than a quarter inch. Participants under the age of eighteen and over the age of thirty years of age were also excluded.

### **Materials**

A Shekel Postural Scale Analyzer- model GPS-200, Posture Scale Analyzer, Midot Meditech US, 735 Elm Ave, Suite 3c, Teaneck, NJ 07666, USA was used. The Shekel posture scale analyzer is a quadruped scale with 4 digital force plates. It provides numeric and graphic data on weight distribution, total weight, and percentage weight difference between left and right lower extremities.<sup>31</sup> The scale is accurate to 1/100 of a pound.<sup>31</sup>

A single strap shoulder bag was used. This bag was designed specifically as a single strap bag and not a backpack worn over one shoulder (see figure 1). The bag measured 15 X 11 X 5 inches and weighed 10 pounds in its entirety. It was weighed each of the three days it was used prior to testing. Ten pounds was chosen because this is a comfortable weight and below the recommended 10 to 15% of body weight for all individuals. The investigators wanted to keep the weight of the bag constant for all participants and lower than the recommended carrying weight of 10 to 15% to avoid placing excessive loads on the participants' shoulders.<sup>10,14</sup>

### **PROCEDURE**

Two investigators performed the same task on each testing occasion. Investigator 1 measured for leg length differences and obtained demographic information (see appendix 1 for the evaluation form). Investigator 2 ran the software needed for the scale and recorded the weight through each lower extremity. Sixty-five participants were tested over three days under consistent conditions consisting of the same room, single strap bag, table, and scale set up.

Participants met with Investigator 1 at station 1 to collect demographic data such as age, gender, and hand dominance. A short questionnaire was answered by each participant to ensure they met the inclusion criteria for the study (see appendix 1). Each participant then had his or her standing and recumbent leg lengths measured with a tape measure to ensure he or she qualified for the study. Leg length was measured from the anterior superior iliac spine (ASIS) to the medial malleolus in supine.

Each qualified participant then proceeded to Investigator 2 at station 2. The participant removed his or her footwear and was then weighed on the scale for both total weight and weight distribution through both legs (see figure 1). Participants placed their feet along a foot silhouette on the scale (see figure 2). If the participant had more than a 2% variance in the weight distribution through both lower extremities, a dominant weight bearing (WB) lower extremity was determined. Those that bore more weight through their right leg were deemed right lower extremity weight bearing dominant for the purposes of this study. Those that bore more weight through the left leg were deemed left lower extremity weight bearing dominant. It was determined that individuals who bore weight equally through each leg were those individuals who had less than a 2% difference in weight placed through each lower extremity.

**Figure 1**



**Figure 2**



The participant then donned the shoulder bag on the non-dominant shoulder. The strap was adjusted so that the bag would sit at the contralateral ASIS. The participant stepped barefoot onto the scale (see figure 3) and the weight through each lower extremity was recorded. A second condition was then created by wearing the shoulder bag on the dominant shoulder draped across to the contralateral ASIS. The participant once again stepped on the scale, and the weight through each lower extremity was then recorded. Both conditions were repeated for all 65 participants.

**Figure 3****Operational Definitions**

*Across the body draped* – Wearing a shoulder bag with the strap over one shoulder running diagonally across the body with the bag resting at the contralateral hip. Example, right shoulder draped – indicated the strap was over the right shoulder draped diagonally across the body with the bag sitting at the left hip.

**Data Analysis**

SPSS version 10 was utilized to perform a one-way analysis of variance to determine statistical significance. SPSS was also used for further data analysis consisting of frequencies, chi-square and independent t-tests. Significance was set at  $p < .05$ .

**RESULTS**

The participants in this study consisted of sixty-five college students. Forty-seven participants were female and 18 were male. Sixty-three of the sixty-five participants were right hand dominant. Pearson's Chi-Square was run to determine if there was a significant difference between hand dominance in males and females and no significant difference was found ( $p > .05$ ). The mean weight for all participants was 153.0 pounds. The mean weight for female participants ( $140.9 \pm 21.6$  pounds) was significantly different ( $p < .05$ ) than the weight for the male participants ( $184.8 \pm 34.9$  pounds). Mean age was 24.8 years. Mean age for females was  $24.3 \pm 2.1$  years, mean age for males was  $26.1 \pm 2.3$  years.

Thirty-four participants were right lower extremity WB dominant, twenty-one participants were left lower extremity WB dominant and ten participants had equal lower extremity distribution. An independent samples t-test was run to determine whether upper extremity hand dominance correlates to lower extremity WB dominance. There was no significant difference found ( $p > 0.05$ ).

One-way analysis of variance was used to determine whether a shoulder bag can be utilized to equalize the lower extremity weight distribution in static standing. Table 1 depicts the results of the one-way analysis of variance. A significant improvement ( $p < 0.05$ ) in weight distribution was found in right hand dominant subjects ( $n = 63$ ) when wearing a shoulder bag draped across left shoulder to right hip. There was no significant improvement ( $p > 0.05$ ) found when right hand dominant subjects wore a shoulder bag draped across right shoulder to left hip. For individuals that are left shoulder dominant ( $n = 3$ ), no significance was found in either of the carrying positions. Table 1 shows the average percentage weight distribution through each lower extremity for all right handed participants. The scenarios include baseline, when the shoulder bag draped over the right shoulder (RSD) and



when the shoulder bag draped over the left shoulder (LSD). Note that when the right handed participants wore the shoulder bag draped over their left shoulder the average percentage weight bearing through each lower extremity became closer in value as compared to in the right shoulder draped scenario.

**Table 1**

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
LLELSD	Equal variances assumed	2.135	63	0.037*	3.451
	Equal variances not assumed	3.605	4.467	0.019*	3.451
LLERSD	Equal variances assumed	-0.827	63	0.411	-1.570
	Equal variances not assumed	-0.582	3.181	0.599	-1.570
RLELSD	Equal variances assumed	-2.135	63	0.037*	-3.451
	Equal variances not assumed	-3.605	4.467	0.019*	-3.451
RLERSD	Equal variances assumed	0.771	63	0.44	1.406
	Equal variances not assumed	0.522	3.165	0.636	1.406

*RLERSD* – Right lower extremity, right shoulder draped. (Weight is measured through the right lower extremity. Bag is worn on the right shoulder, draped across the body).

*LLERSD* – Left lower extremity, right shoulder draped. (Weight is measured through the left lower extremity. Bag is worn on the right shoulder, draped across the body)

*RLELSD* – Right lower extremity, left shoulder draped. (Weight is measured through the right lower extremity. Bag is worn on the left shoulder, draped across the body).

*LLELSD* – Left lower extremity, left shoulder draped. (Weight is measured through the left lower extremity. Bag is worn across the left shoulder, draped across the body).

\*Denotes significant.

\*\*Non-dominant left shoulder participants were the majority in this study

## DISCUSSION

There are many types of backpack designs including shoulder bags, traditional double strap backpacks, and hand carried bags. Despite warnings issued by various professional organizations regarding the harmful effects of carrying unevenly distributed heavy loads, students continue to carry shoulder bags over one shoulder of self-selected body side.<sup>1</sup> The purpose of this study was to determine whether there is a way to carry a single strap shoulder bag that allows equalization of weight bearing through the legs thereby reducing postural asymmetry. If a shoulder bag carried in a particular manner can minimize asymmetries in weight bearing, it was hypothesized that it would allow for a more even distribution of load bearing pressures through the joints of the lower extremities and spine and ultimately reduce occurrence of back pain and other musculoskeletal problems.

Results indicated that when the individual is right hand dominant and wears the shoulder bag left shoulder draped, the weight distribution through the person's lower extremities became more equal. This was significant whether the individual exhibited increased weight bearing through the right or left lower extremity initially. For left shoulder dominant individuals, no significance was found in either of the carrying positions. As there were only three participants that fit into the left dominant group, there was insufficient power to determine statistical significance.

Based on the findings, it is theorized that carrying a shoulder bag with a unilateral strap on the non-dominant shoulder draws the shoulder closer to the height of the dominant shoulder, facilitating more symmetrical posture and equalizing weight bearing through the lower extremities in static standing. The results and conclusions of this study may not be generalized to all populations, as it was limited to healthy college age adult students.

### Future Studies

There were limitations to this study. It was conducted with predominantly right handed people, who constitute the majority of the general population. For future studies, it would be prudent to investigate whether the results could be replicated in an equally sized population of left handed individuals, as well as in those who are ambidextrous. This study did not evaluate the effects of shoulder bag size as a percentage of each individual participant's weight, pre-determining bag weight, which may also have impacted the results, as the literature suggests that individuals should carry a limited percentage of their own body weight in any type of backpack. Subtle long term changes were not identified as this study looked only at immediate changes in static weight bearing. It would be of interest to compare static standing to the weight distribution during dynamic gait and determine the effects. Another recommendation would be to investigate specific lower extremity joint loading pressures over time and the long term postural effects.

### CONCLUSION

The results of this study identified that it is possible to wear a single strap shoulder bag in a certain way to reduce postural asymmetry in static standing. Right hand dominant individuals who wore a shoulder bag draped over their left shoulder demonstrated more evenly distributed weight through their lower extremities despite which one exhibited increased weight bearing initially. Results suggest that it may be beneficial, in the short term, for students who use a unilateral strap shoulder bag to carry it draped across their non-dominant shoulder in order to equalize weight bearing through their lower extremities.

Students currently continue to require a mode of carriage for their school supplies. Although the future may change this with the use of lightweight laptops and other smart devices, the potential to develop musculoskeletal problems should not be ignored. Heavy items such as textbooks that may overload a shoulder bag are still in use and require transport at minimum between school and home. It is therefore of importance to identify the most ideal way for students to wear a single strap shoulder bag if it is the bag of choice. The importance of this extends to all individuals who carry bags of this type for optimal and more balanced placement of forces throughout the body.

The implementation of shoulder bag carriage analysis by physical therapists has positive implications for shoulder bag carriers. Appropriate education at all levels of education could be beneficial in prevention of back pain and related musculoskeletal problems as suggested by this study. Although the results of this study are for static standing only, prevention of postural asymmetries during dynamic gait may ultimately be key to managing biomechanical and back pain problems in adults.

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#### KEY TERMS

Shoulder Bag, Postural Scale Analyzer, Dominant and Non-Dominant Hand, Lower Extremity, Weight Distribution, Postural Asymmetry, Postural Symmetry



## APPENDIX 1

## SHOULDER BAGS: CAN THEY BE WORN IN A WAY TO REDUCE POSTURAL ASYMMETRY?

Code: \_\_\_\_\_

## Section A: Demographic Information

1. Age: \_\_\_\_\_
2. Weight (in lbs.) \_\_\_\_\_
3. Student? Yes \_\_\_\_\_ No \_\_\_\_\_
4. Gender (check one): Male \_\_\_\_\_ (1) \_\_\_\_\_ Female (0)
5. Dominant Hand (check one): Right \_\_\_\_\_ Left \_\_\_\_\_

## Section B: Examination

	Yes	No
1. Have you had any trauma or injury to your hip, knee or ankle in the last six months?		
2. Have you had any other musculoskeletal injury or trauma in the last three months?		
3. Are your legs more than ¼ inch different in length? (Subject does not know _____)		

*Researcher:* Excuse from the study, any subject who answers "yes" to any of the above questions or who refuses to answer any of the above questions.

## Section C: Leg Length Measurements

*Researcher:* Say, "Please stand up straight with your weight evenly distributed on both feet while I measure your leg length."

	Right Leg	Left Leg
Length from ASIS to medial malleolus (inches)		

*Researcher:* Say, "Please lay down on your back with your legs stretched out flat on the treatment table while I measure your leg length again."

	Right Leg	Left Leg
Length from ASIS to medial malleolus (inches)		

*Researcher:* Excuse from the study, any subject with a leg length discrepancy of more than ¼ inch.

## Section D: Weight Distribution

*Researcher:* 1<sup>st</sup> two trials Say, "I want you to put the bag over your \_\_\_\_\_ (left, right) shoulder with the strap draped across your body, and step up onto the scales with one foot on each scale."

Bag over:	Left Shoulder/draped	Right Shoulder/draped
Left lower extremity		
Right Lower extremity		