

## ORIGINAL ARTICLE

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## EFFECT OF SHOULDER SIDE PACK ON DYNAMIC POSTURAL STABILITY IN YOUNG HEALTHY FEMALE

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## ABSTRACT

**Background:** Control of balance is a complex motor skill that involves integration of sensory inputs and the planning and execution of flexible movement patterns. Carrying side packs is famous in our society especially shoulder side packs. Most students carry shoulder side packs and they don't care about the way to carry them to be more balanced. The purpose of the study is to investigate the effect of carrying shoulder side pack on dynamic postural stability and to determine the best way of carrying a shoulder side pack either on the dominant side or non-dominant side that doesn't affect dynamic postural stability in young healthy female.

**Methods:** Sixty female volunteers aged from 18 to 25 years old participated in the study. Biodex balance system was used to measure the dynamic postural stability in three different occasions (without carrying a shoulder side pack, with carrying a shoulder side pack on the dominant side, and on the non-dominant side) with a rest period in between.

**Results:** Repeated measure analysis of variance (ANOVA) followed by Bonferroni post hoc test were used to compare dynamic posture balance without carrying and during carrying a shoulder side pack on dominant and non-dominant sides. Analysis revealed that overall, anteroposterior and mediolateral stability indexes reduced significantly ( $P < 0.0001$ ) when carrying shoulder side pack on dominant side in comparison with when carrying shoulder side pack on non-dominant side and without carrying bag.

**Conclusion:** It was concluded that carrying a shoulder side pack on the non-dominant side didn't disturb the postural stability when compared to carrying on the dominant side so, we recommend the students to carry shoulder side packs on the non-dominant side.

**Keywords:** balance, biodex balance system, dynamic postural stability, shoulder side pack, stability index, young healthy female.

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## INTRODUCTION

Dynamic postural stability is the ability to maintain postural stability and orientation with center of mass over the base of support while the body parts are in motion [1]. Integrated sensory information from the visual, proprioceptive and vestibular systems maintain the unstable human upright posture [2,3]. Control of balance is a complex motor skill that involves integration of sensory inputs and the planning and execution of flexible movement patterns [4]. Foot placement, addition of external loads, forces and surface condition can alter these inputs [5].

During quiet erect stance, an external load seems to negatively affect balance control, since such loads resulted in increased postural sway. The increase in postural sway brings the whole body center of mass (COM) closer to the limits of the base of support (BOS) which makes the body less stable [6,7]. Many occupational and daily living activities need load carriage as carrying bags [7]. More than 90% of school children in developed countries carry some type of shoulder side pack [8,9]. There are a number of students of all ages who prefer to carry one-strap shoulder bag. About 55% of high school students carried their shoulder side packs asymmetrically and most of the reports demonstrated that loads carried by students are greater than the recommended limits [10].

Carrying a shoulder bag for prolonged periods of time can have negative effects on the human body. The position of a single sided shoulder bag's strap may lead to different musculoskeletal compensations and postural asymmetries [11,12]. Repetitive periods of postural asymmetry can lead to asymmetric muscular activity which may contribute to the development of chronic shoulder, neck and back pain [12]. Despite the warnings about harmful musculoskeletal effects of carrying shoulder side packs, students continue to use it because of its convenient uses [13].

Although, several studies were performed to investigate the impact of load carriage on energy cost and its effect on gait parameters, very few studies investigated the problem of stability and balance control while carrying heavy load [14-20]. Furthermore, as the dominant shoulder is lower in position than the non-dominant shoulder, [21] [22] [23] carrying the shoulder side pack either on the dominant or non-dominant shoulder may create different effect on balance control and postural stability. To the best of our knowledge there is a paucity of literature that investigated the effect of the position of the load either on the dominant or non-dominant side, [20] [21] [22] [23] so, this study aimed to investigate the effect of carrying shoulder side pack on dynamic postural stability either on dominant or non-dominant sides in healthy female subject.

## MATERIAL AND METHODS

Sixty healthy female subjects who ranged between 18 to 25 years were inspected and selected randomly from the students of the Faculty of Physical Therapy, Cairo University, to join this study. The participant's body mass index (BMI) ranged from 18.5 to 25 kg/m<sup>2</sup> and all the participants were

right hand dominant. The demographic data of the participants is shown in Table 1. Exclusion criteria involved the participants with any history of perceptual deficits, any musculoskeletal disorder in upper or lower extremities, or spine, any surgical operations in lower limbs, or any neurological disease which may impair their performance. The ethical committee of the Faculty of Physical Therapy in Cairo University approved this study. A consent form was signed by each participant, accepting to participate and publish the findings of the study.

Each participant passed by three conditions; one unloaded condition and two loaded conditions. The two loaded conditions are carrying shoulder side pack on the dominant side (right side) and on the non-dominant side (left side). The shoulder side pack weight was 15% of participant body weight with measurements of 15x12x3 inches. Within 15% of body weight there were no marked changes in trunk posture, gait pattern and no muscle fatigue according to Hong and Cheung 2003 [24], and Hong et al. 2008 [25]. The length of bag strap was adjusted for every participant from acromion process to anterior superior iliac spine. Dynamic postural stability level was assessed in the three previous conditions with Biodex stability system (BSS).

Each participant passed with three conditions of dynamic postural stability evaluation; first condition without carrying side pack, second condition while carrying the shoulder side pack on the dominant side (right side) and the last condition while carrying the shoulder side pack on the non-dominant side (left side).

### Biodex Stability System

BSS is a device that can effectively measure postural stability under dynamic stress. It assesses neuromuscular performance by evaluating the ability of remaining stable on the unstable platform [26]. The platform is connected to a computer software that enables the device to serve as an objective assessment of balance [27]. The BSS uses a circular platform that is able to move along the anterior-posterior and medial-lateral axes simultaneously. BSS measures the tilt about each axis during dynamic conditions and computes the overall stability index (OSI), mediolateral stability index (MLSI), and anteroposterior stability index (APSI) in degrees. Prior to testing when the platform is stable, these indexes represented fluctuations around a zero point [28]. The subject's ability to control the platform angle of tilt and the amount of platform motion reflected the stability index (SI). A high SI indicates a lot of movement and consequently less stability. On the other hand, a lower SI indicates a better balance score. At the end of the test comprehensive report appeared on the screen for each testing occasion.

BSS was used for assessment of the dynamic postural control of all participants in the three different conditions by using dynamic postural stability test to measure OSI, APSI and MLSI with stability level (4). The BSS permits up to 20° of foot platform tilt which allows the ankle joint mechanoreceptors to be stimulated maximally. The platform

stability can be changed by adjusting the level of resistance given by the springs under the platform. The stability of the platform is from 1 to 8, as 8 indicates the maximum stability and 1 the least stability. As the resistance level lowers the platform becomes less stable [29].

### Dynamic postural stability measurement procedure

Firstly, a complete explanation of the study, its objectives and procedures were given to each participant. This includes an orientation with biodex stability system (BSS), its parts, testing steps and test outcomes. Each participant was tested on BSS for 40 sec with platform stability level (4) with open eyes.

The participant stood on the BSS without footwear. Then the participant was instructed to stand upright looking straight and assume a comfortable erect posture with body weight evenly distributed. The participant was instructed to shift the position of his feet until the cursor on the visual feedback screen is centered on the screen grid once the platform set to motion. Each participant was tested under three conditions (without carrying any load, with carrying a shoulder side pack on the dominant side (right side) with load 15% of body weight, with carrying a shoulder side pack on the non-dominant side (left side) with load 15% of body weight).

The 15% of body weight load was chosen according to American Occupational Therapy Association 2006 [30], Hong and Cheung 2003[24], and Hong et al. 2008 [25] as it doesn't cause any changes in trunk posture or muscle fatigue. The bag's weight was adjusted to 15% of body weight using sand bags which put inside the bag according to the weight of the participant. The participants were instructed to rest for three minute after each test condition to prevent any possible effect of muscle fatigue that might affect the results. The measurements of overall OSI, APSI and MLSI were recorded for each student under each of the three conditions.

### Statistical Analysis

The SPSS (version 17) statistical software package was used for statistical analyses. the normality of the data was first analyzed using the Shapiro-Wilk test and Kolmogorov-Smirnov test. All data are expressed as mean and standard deviation. A significance level  $p < 0.05$  was used. Repeated measure analysis of variance (ANOVA) followed by Bonferroni post hoc test were used to compare dynamic postural stability without carrying any load and during carrying shoulder side pack on dominant and non-dominant side. A sample size of over 50 subjects was appropriate to have more than 80% power after conducting a statistical power analysis.

## RESULTS

This study was conducted on 60 healthy female subject. The demographic data of the participants is shown in table 1. Dynamic postural stability in the form of OSI, APSI, and MLSI were measured without carrying any load, with carrying a shoulder side pack on the dominant side with

load 15% of body weight, and with carrying a shoulder side pack on the non-dominant side with load 15% of body weight as shown in table 2.

**Table 1:** Participants' demographic data

Items	Mean	±SD
Age (years)	21.1	±2.1
Weight (Kg)	62.2	±10.4
Height (Cm)	162.1	±8.9
BMI (Kg/m <sup>2</sup> )	23.2	±1.7

SD: standard deviation

**Table 2:** OSI, APSI, and MLSI at the three different occasions

Dynamic postural stability	Without carrying a side pack	carrying a shoulder side pack on the dominant side with load 15% of body weight	carrying a shoulder side pack on the non-dominant side with load 15% of body weight	P-value
Overall stability index	3.04±1.07	3.76±1.18	3.23±1.08	$P < 0.0001^*$
Anteroposterior stability index	2.45±0.82	3.42±1.04	2.64±0.84	$P < 0.0001^*$
Mediolateral stability index	2.31±0.9	2.88±1.14	2.51±0.94	$P < 0.0001^*$

\*significant

### Overall stability index:

There was significant difference in OSI between the three conditions ( $P < 0.0001$ ) as revealed by repeated measure (ANOVA). The OSI while carrying shoulder side pack on dominant side was significantly difference from OSI in standing without carrying any load ( $P = 0.0001$ ) which resulted by Bonferroni post hoc test. While the OSI during carrying shoulder side pack on non-dominant side was not significant from OSI in standing without carrying any load ( $P = 0.11$ ) which resulted by Bonferroni post hoc test. Finally there was a significant difference between OSI during carrying shoulder side pack on dominant and OSI during carrying shoulder side pack on non-dominant side ( $P = 0.0001$ ) which resulted by Bonferroni post hoc test.

### Anteroposterior stability index:

There was significant difference in APSI between the three conditions ( $P < 0.0001$ ) as revealed by repeated measure (ANOVA). The APSI in standing without carrying any load was significantly difference from APSI during carrying shoulder side pack on dominant side ( $P = 0.0001$ ) as gained by Bonferroni post hoc test. There was no significant difference between APSI in standing without carrying any load and APSI during carrying shoulder side pack on non-dominant side ( $P = 0.13$ ) as gained by Bonferroni post hoc test. Finally there was a significant difference between APSI during carrying shoulder side pack on dominant and non-dominant side ( $P = 0.0001$ ) as gained by Bonferroni post hoc test.

## Mediolateral stability index:

There was significant difference in MLSI between the three conditions ( $P < 0.0001$ ) as revealed by repeated measure (ANOVA). The MLSI in standing without carrying any load was significantly different from MLSI during carrying shoulder side pack on dominant side ( $P = 0.0001$ ) as obtained by Bonferroni post hoc test. There was no significant difference between MLSI in standing without carrying any load and MLSI during carrying shoulder side pack on non-dominant side ( $P = 0.1$ ) as obtained by Bonferroni post hoc test. Finally MLSI during carrying shoulder side pack on dominant side was significant difference from MLSI during carrying shoulder side pack on non-dominant side ( $P = 0.0001$ ) as obtained by Bonferroni post hoc test.

## DISCUSSION

Our current study showed that dynamic postural stability reduced significantly when carrying shoulder side pack on dominant side with load equivalent to 15% of body weight. While carrying shoulder side pack on non-dominant side with a load of 15% of body weight didn't affect dynamic stability.

The results of the current study may be attributed to the posture of the shoulder as the dominant shoulder is lower in position than the non-dominant shoulder [21] [22] [23]. Wearing a shoulder side pack on the shoulder that is lower may create further asymmetries to posture and move the center of gravity outside the base of support which alter weight bearing distribution through the lower extremities. So, carrying shoulder side pack on dominant side could disturb the dynamic postural stability.

The Results of this study were supported by several studies. Heller et al. who studied the effects of carrying external weight on postural stability reported that the carrying of heavy packs as an external load affect postural stability and make the subjects less stable [31]. In addition, Mackenzie et al proved that a bag with a weight exceeding 15% to 20% of body's weight may lead to back pain, moreover, the use of pack improperly can associated with abnormalities of posture and gait. They also reported that the unilateral load carrying wasn't equally distributed in the frontal plane which supports the findings of this study [32]. Furthermore, Andersson et al reported that job environment or handedness may bias a preferred side for carrying loads asymmetrically unilaterally which predisposes high level of moment and force located contra laterally to the carried load [33].

The COM of an unloaded body is located approximately anterior to the second sacrum vertebrae. In the case of carrying load, the COM of the body reflects the effect of the load added to the body. So, there is a need to control the position of the combined COM in space. Thus the load carried during one-strap bag carriage reinforces lateral spinal bending and elevation of the shoulder from a horizontal position [34].

The results of the current study came in agreement with

Sutton et al who found that carrying load in form of bag lower the postural stability in mediolateral direction in elderly. Furthermore, they reported that the lowering of the postural stability in the mediolateral direction is correlated with falls in eld [35].

Studies which examine the effects of external loads during upright stance on balance control, Qu and Nussbaum reported that the application of external loads changes balance control due to the mechanical changes induced by the loads [36]. Also, Costello et al investigated the change in body balance after adding external weight. They found that adding weight had a negative effect on balance [37]. As, the shoulder side pack is considered one of the forms of adding weight to the body, so it can affect dynamic postural stability. In addition, Smith et al reported that long term carrying of shoulder bag could cause persistent postural deviation in female college students due to altered pelvic rotation during gait and this also could affect postural stability [38].

The result of this study supported also by the results of Qureshi and Shamus who stated that wearing a shoulder bag draped across the non-dominant shoulder improved postural symmetry in static standing which revealed by equal weight distribution through the subject's lower extremities [39].

The results of our study may help in determining the best way for carrying shoulder side pack either on the dominant side or the non-dominant side in young healthy female. Carrying a shoulder side pack on the non-dominant side was shown to be safer and maintains dynamic postural stability than carrying side pack on the dominant side. One possible limitation of the current study is the confining of participation in the study on female. Another possible limitation is that only a load equivalent to 15% of body weight was used, may be different results were obtained if the different load weights were used.

So, future studies are required to study the effect of shoulder side pack on dynamic postural stability in males and with different weights of side pack loading. Also, the use of various postural analysis devices to compare between carrying a shoulder side pack on dominant and non-dominant side is recommended. Further studies are also required to study the myoelectrical activity of different trunk, neck and shoulder muscles during asymmetric shoulder side pack carrying to give a complete picture about the best way of carrying side pack.

## CONCLUSION

According to the findings of this study, it was concluded that carrying a shoulder side pack on the non-dominant side didn't disturb the dynamic postural stability when compared to carrying it on the dominant side.

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