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Influence of Ordinary Backpack versus Modified Double Sided Bag on Dynamic Balance

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ABSTRACT

The Purpose: To compare between dynamic balance level while carrying no pack with that while carrying the ordinary backpack and modified double-sided bag style in children. **Methods:** Thirty school children aged between 8 to 12 years were assigned in one group underwent dynamic balance evaluation without carrying load and with carrying load (15% of body weight); once with ordinary backpack and another with modified double sided bag. Dynamic balance level was assessed by Biodex Stability System. **Results:** There were no statistically significant differences between all variables; Overall stability index (P value=0.11), Anterior/Posterior stability index (P value=0.12) and Medial/Lateral stability index (P value=0.11) among the three previous conditions. **Conclusion:** Students weren't susceptible to balance disturbance when carrying any of the two bags with load 15 % of their body weight.

Key words: Backpack, Modified double-sided bag, Dynamic balance.

INTRODUCTION

Human upright posture is inherently unstable and is maintained by continuous response to integrated sensory information from the visual, proprioceptive and vestibular systems. Factors which have an impact on any of these sensory systems or the feedback mechanism may affect stance stability and balance[6].

Load carrying is one of the most common human activities .It is accomplished by placing the load on one's shoulder, back or head. The most typical form of carrying involve the hands and/or arm .Because of its world wide prevalence across various occupational and domestic setting, the development of safe load limits is important in the evaluation and design of carrying activities[20].

When a load is carried, the mass of load becomes part of the body mass. Therefore it alters the location of COG location of the whole system (body and load).For balance to be maintained, the body's base of support is to be adjusted for the new location of the line of gravity[4].

By adding more weight to the back of the body, the COG is shifted towards the rear of the base of support both for children and adults. In response to this change, subjects naturally shift their trunk segments either backward or forward in order to counterbalance the load of the backpack. Many researchers found out that when the load of the backpack is increased, the degree of the trunk forward lean also increased[1].

If the use of a backpack results in a change in the COG with an accompanying alteration in muscle recruitment that would be needed to maintain balance or posture, the continued use of such a pattern may promote long term undesirable coactivation of agonists and antagonists increasing joint compression and total load in the spine and extremities[28].

Bilateral backpack carrying minimizes muscular requirements on both sides of the spine. Carrying a backpack on one shoulder tends to increase the lateral flexion moment about the spinal column. Thus, the individual who continuously uses a one sided carrying technique may be prone to fatigue due to increased muscular activity on the side opposite the load. In addition, increased muscular activity indicates greater compressive forces on spinal structures[8,27].

Intensive studies were performed to discover the impact of load carriage on energy cost, the influence on gait parameters, effect of load distribution and sex differences. On the other hand the problem of stability while carrying heavy load has not been much investigated[25]. Existing studies of external loads, however, have been somewhat narrowly focused on the effects of external load mass on balance control[23]. So the purpose of this study is to compare between dynamic balance level while carrying no pack with that while carrying the ordinary backpack and modified double-sided bag style in children.

MATERIALS AND METHODS

Subjects

Thirty school students of both sex, aging between 8 and 12 years were assigned in a single group. They were all normal children have no muscloskeletal deformities, can follow instructions. The study design was one group pre-post design The group passed by three conditions; one unloaded condition and two loaded conditions. The two loaded conditions; one with the ordinary backpack and the other with double sided bag style. Dynamic –balance level was assessed in the three previous conditions with Biodex Stability system (BSS). The students and their parents were informed about the test and its aim, and parents signed consent form.

Instrumentations

Biodex Stability System

Medical system INC. Brook haven technology center is a dynamic postural stability assessment, which assesses neuromuscular performance by evaluating the ability of remaining stable on the unstable platform[29]. The platform is interfaced with computer software that enables the device to serve as an objective assessment of balance[17].

Mechanism of the balance system

This system is consisted of a movable balance platform, which provides up to 20◦ of surface tilt in a 360◦ range. The motion of the unstable platform is represented as deviations from the horizontal plane (Overall stability index "OSI", Anterior/Posterior stability index "AP", Medial/Lateral stability index "ML"). The platform provides eight different stability levels, which range from a completely firm surface to a very unstable surface. The platform provides eight different stability levels, which range from a completely firm surface to a very unstable surface[24].

Bags

There were two bag styles used by each student, the first was the ordinary backpack used by all students. The second one, was an ergonomically designed bag (modified double sided bag style).

The ordinary backpack

It was a double strapped backpack which is one of the ordinary backpack styles presented in the markets with dimensions of 44 X 30 X 15 cm. figure (1).

The modified double sided bag style

The bag dimensions were determined according to the anthropometric measures of a sample of 100 Egyptian students of the same age[19].

It is composed of:

It is composed of two Side bags allow vertical weight loading for balanced upright posture, adjustable padded shoulder straps accommodate different body heights, adjustable front-hip buckle closure allows child to sit and remove the load while compartments remain at his sides and accessible. Adjustable back belt (figure 2).

Methods

Each student passed with three conditions of dynamic balance evaluation; first condition while carrying no load, second condition while carrying the ordinary backpack and the last condition while carrying the modified double sided bag.

Fig. (1)

Fig. (2)

Balance measurement procedure

Firstly, a complete explanation of the study was conducted for each student. Subject's weight and height were measured using ordinary scale. Select the dynamic balance testing from the operation system. Platform stability level was chosen (8-5) with opened eyes.

The BSS allows up to 20° of foot platform tilt, which permits the ankle joint mechanoreceptors to be, stimulated maximally[15]. The stability of the platform can be varied by adjusting the level of resistance given by the springs under the platform. The platform stability ranges from 1–8, with 1 representing the greatest instability. The lower the resistance level the less stable the platform[3,12].

In this study, the platform stability was decreased from level 8 to level 5 within 40 sec that is because lower stability levels on the BSS may not be appropriate for use as an objective marker of progression due to poor reliability of the scores over time[9]. Level 2 would be too unstable for some participants. Conversely, levels 6 through 8 had superior reliability and at level 5 we found that our subjects started to experience instability. Therefore, we have selected the range from 8 to 5 to be the stability level[22].

Student Position

The student ascended to the BSS's locked platform without footwear. Then she/he was instructed to stand upright looking straight and assuming comfortable erect posture with body weight evenly distributed. The subject was instructed to shift the position of his feet until the cursor is centered on the screen grid . Then the researcher identifies the subject's feet position on the platform through recording the heel coordinates and foot angle Fig (3). The center of the heel was identified by a point of intersection of horizontal lines, represented in characters, and vertical lines, represented in numbers. The angle of the foot was determined by the line which is parallel to the second metatarsal. All these values were recorded on the system and used in reevaluation to ensure consistency of the tests using the same test position.

Fig. (3): Represents feet coordinates and angles.

Testing Conditions

Subjects were tested under three conditions: 1-without carrying load, 2-two carrying load conditions (15% of body weight); once carrying the ordinary backpack and the other, carrying modified double sided bag with weight equally distributed on both sides. This percentage of weight was chosen according to Shasmin et al.,[26] and Hong et al.,[14].

The subjects were instructed to rest on a chair beside the system for three minute after each test condition to prevent fatigue that might affect the results[18].

The measurements of OSI, AP Stability Index and ML Stability Index were recorded for each child under each of the three conditions. A high number indicated greater motion and difficulty with maintaining stable while a low number indicates less motion and greater ability to maintain stable[5]. At the end of the test comprehensive report appeared on the screen for each testing occasion, which includes over all stability level score, mediolateral and anteroposterior stability scores.

Statistical Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS version 16). Repeated measurement ANOVA was used to evaluate the statistical difference in OSI, AP stability index and ML stability index between the tested conditions, without carrying any load, carrying the ordinary backpack and carrying the modified double sided bag.

RESULTS

Physical characteristics of the Subjects

In this study, 30 subjects were participated in this study. The physical characteristics of the subjects are presented in table (1):

Table (1): Physical characteristics of the subjects.

Item	Mean	±SD
Age (yrs)	9.6	±1.3
Weight (Kg)	31.76	±4.92

SD= standard deviation

Dynamic balance test (overall stability index)

The group means and SDs for OSI without bag (unloaded), with ordinary bag, and with modified bag shown graphically in Fig. (4).

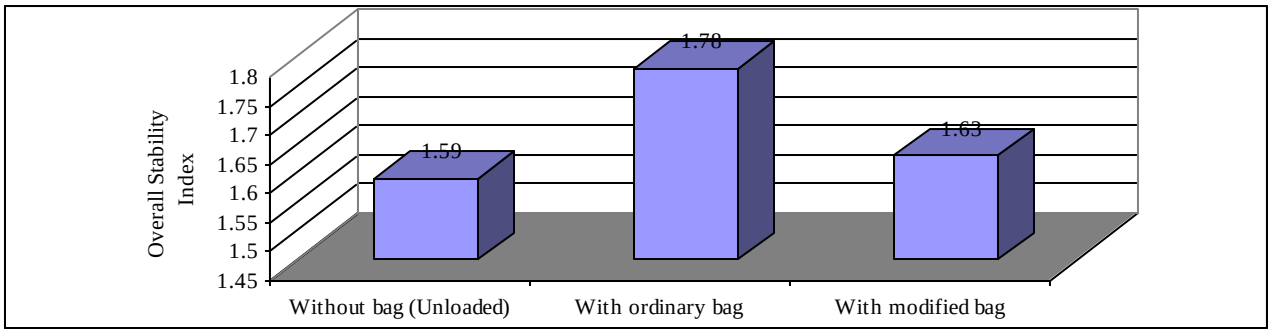

Fig. (4): Mean and ±SD of OSI without bag (unloaded), with ordinary bag and with modified bag.

Within subjects Changes

The within subjects change of the OSI without bag (unloaded), with ordinary bag, and with modified bag are presented by application of the repeated measurement ANOVA as shown in table (2).

Table (2): Repeated measurement ANOVA of Overall Stability Index without bag (unloaded), with ordinary bag, and with modified bag.

Source of variation	SS	DF	MS	F	P	S
Within subjects	0.6	2	0.3			
Between subjects	5.14	29	0.17	2.2	0.11	NS
Error	7.91	58	0.13			

SS: Sum of square MS: Mean square S: significant DF: Degree of freedom NS: non-significant

Dynamic balance test (Anteriorposterior stability index)

The group mean and SDs for AP Stability Index without bag (unloaded), with ordinary bag, and with modified bag are shown graphically presented in Fig. (5).

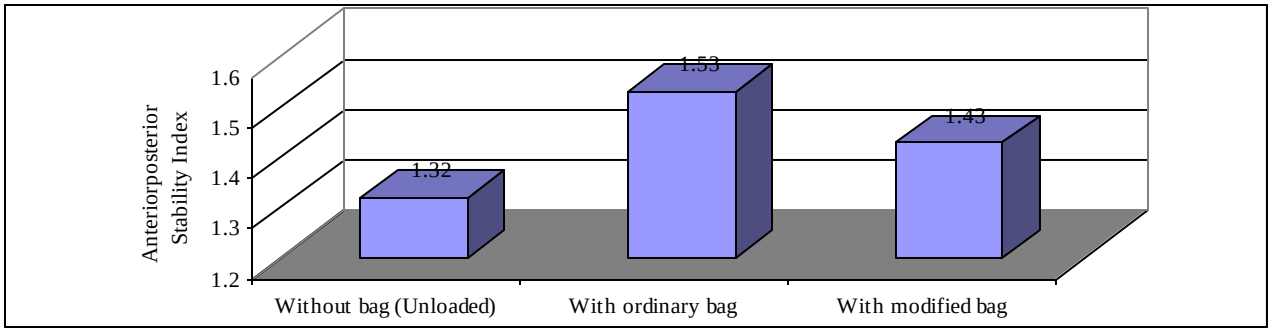

Fig. (5): Mean and ±SD of AP Stability Index without bag (unloaded), with ordinary bag, and with modified bag.

Within subjects Changes

The within subjects change of the AP Stability Index without bag (unloaded), with ordinary bag, and with modified bag are presented by application of the repeated measurement ANOVA as shown in table (3).

Table (3): Repeated measurement ANOVA of AP Stability Index without bag (unloaded), with ordinary bag, and with modified bag.

Source of variation	SS	DF	MS	F	P	S
Within subjects	0.68	2	0.34			
Between subjects	3.69	29	0.12	2.19	0.12	NS
Error	9.03	58	0.15			

SS: Sum of square MS: Mean square S: significant DF: Degree of freedom NS: non-significant

Dynamic balance test (Mediolateral stability index)

The group means and SDs for ML Stability Index without bag (unloaded), with ordinary bag, and with modified bag are shown graphically presented in Fig. (6).

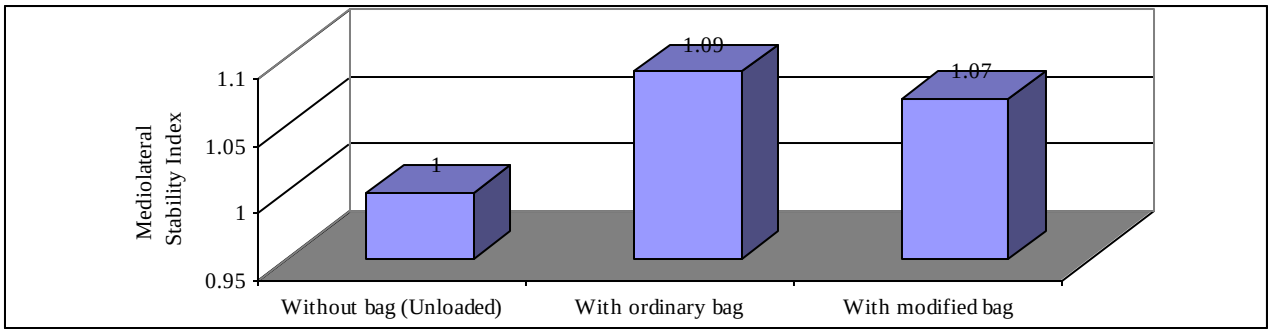

Fig. (6): Mean and ±SD of ML Stability Index without bag (unloaded), with ordinary bag, and with modified bag.

Within subjects Changes

The within subjects change of the ML Stability Index without bag (unloaded), with ordinary bag, and with modified bag are presented by application of the repeated measurement ANOVA as shown in table (4).

Table (4): Repeated measurement ANOVA of ML Stability Index without bag (unloaded), with modified bag, and with ordinary bag.

Source of variation	SS	DF	MS	F	P-value	S
Within subjects	0.13	2	0.06			
Between subjects	4.4	29	0.15	2.2	0.11	NS
Error	1.72	58	0.02			

SS: Sum of square MS: Mean square DF: Degree of freedom NS: non-significant

DISCUSSION

This study was conducted to compare dynamic balance level, while carrying the ordinary backpack, with that while carrying the modified double – sided bag style. The results of this study showed that the mean overall stability index increased when using both modified double sided bag and the ordinary backpack (1.63 and 1.78) respectively when compared with unloaded condition (1.59) .AP stability index increased when using both modified double- sided bag and the ordinary backpack (1.43 and1.53) respectively when compared with unloaded condition (1.32). Also, ML stability index increased when using each of modified double sided bag and the ordinary backpack (1.07 and 1.09) respectively when compared with unloaded condition (1.0). These increases didn't reach the significant level. Therefore, depending on the previous results we cannot reject the null hypotheses that stated there were no significant differences between the situations of wearing no pack, modified double-sided bag and finally the ordinary backpack.

The present study results was supported by Kim et al.,[16], he stated that using a modified double pack design for improve load distribution and encourage the adoption of erect postures that are present in the no pack condition. Rugelj and Sevek[25] also supported the results of modified double sided bag and postulated that evenly distributed weight didn't affect the sway parameters as when the load is placed in the waist jacket the center of mass position wasn't changed.

Winter[30] stated that no effect was found in respect to backpack load on sway characteristics. Their explanation was that carrying a backpack induces the forward inclination, thereby bringing the position of the combined center of mass (COM) close to the position of the COM in conditions with no backpack.

The present study results agreed with Zultowsk and Aruin[31] he found no significant effect of carrying ordinary backpack with load equal to 15% of body weight and carrying no pack on dynamic balance Their results showed that backpacks do not increase postural sway significantly and their research suggested that a backpack is optimal, as it is the most similar condition to postural sway in the no load conditions.

Findings of this work can be explained according to the study of Hong and Cheung[13] that when individual loaded with a backpack, he will try to shift the center of gravity of the body-/backpack system back to that of an unloaded condition. This can be achieved by forward inclination. This trunk inclination can be explained by the motor control theory. One of the main functions of motor control is to orient the body with respect to the external world, which involves maintaining posture to minimize the disturbance of balance, thus stabilizing the whole body center of gravity.

The COM of an unloaded body is located approximately at S2, anterior to the sacrum. In the case of carrying a load, the COM of the body now 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, for example during backpack carriage, results in the combined COM of the body and backpack shifting posteriorly. In order to preserve the position of the combined COM over the base of support, the individual leans their trunk forward bringing the COM back to its position over the lumbosacral joint[21].

In contrast, Heller et al.,[11] investigated the effect of external weight carriage on postural stability in female subjects and stated that it reduced .This could translate into a higher likelihood of injuries such as ankle sprains in this population. This study results may be differed from our findings due to many reasons, firstly, the average age in that study was 20

years and they were all females, the second point that they were carrying certain weight which is 18 kg while in our study, the child was carrying 15% of his body weight which is the recommendation of American Occupational Therapy Association.

Goh et al.,[10] found that external backpack loading adds stability to the body. The backpack load shifts the center of gravity posteriorly and this is compensated for by an observable forward flexion of the trunk that shifts the center of gravity anteriorly. The forward flexion of the body over the lumbosacral joint, coupled with the external backpack load, create an increase in the mass moment of inertia as body mass and backpack load are balanced. This increase in mass moments of inertia adds stability to the body.

In this research a 15 % of body weight was chosen to be carried by children and that was confirmed by Chansirinukor,2001 who stated that the amount of weight the students are able to carry and maintain their normal postural alignment is between 10% and 17% of the student's body weight. Arnsdroff[2] found that students who carried packs weighing 25% of their body weight exhibit balance problems while performing normal activities such as climbing stairs or opening doors, which in turn increase their risk of falls. In contrast, student who carried packs weighing 15% of their body weight maintained their balance moderately well. Those carrying 5% of their body weight were most effective at maintaining balance, compared with their peers who carried more weight.

CONCLUSION

Based on finding of this study, it was concluded that, with bag load 15% of body weight, the dynamic balance while carrying the modified double-sided bag wasn't not significantly different from the dynamic balance while carrying the ordinary backpack. Therefore, the students are not susceptible to balance disturbance or fall when carrying any of the two bag styles.

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الملخص العربي

العنوان

الهدف من البحث : مقارنة الاتزان الحركي في حال حمل حقيبة الظهر المعتادة بالاتزان الحرك ي في حال حمل الحقيبة المعدلة ذات الجانبين . **التجربة :** وقد أجريت هذه الدراسة في الفترة من ابريل إلى يونيو2011على 30 طفل سليم صحيا (7ذكور و23 إناث) تتراوح أعمارهم من 8-12عاما . وقد خضع جميع هؤلاء الأطفال لتقييم اتزانهم الحركي بدون حمل أي ثقل وبحمل ثقل يعادل 15% من وزن الجسم مرة في حالة حمل حقيبة الظهر المعتادة ومرة أخرى في حالة حمل الحقيبة المعدلة ذات الجانبين . **النتائج :** انه لا يوجد اختلاف ذات دلالات إحصائية في الاتزان الحركي بين الحقيبة المعدلة ذات الجانبين وحقيبة الظهر المعتادة . **الاستنتاج :** لا يوجد اختلاف في الاتزان الحركي بين الحقيبة المعدلة ذات الجانبين وحقيبة الظهر المعتادة عند حمل وزن يعادل 15% من وزن الجسم .

الكلمات الدالة : حقيبة الظهر ، الشنطة المزدوجة المعدلة ، الاتزان الديناميكي .