Influence of Load Carriage on Electromyographic Activities of Upper Fibers of Trapezius in School Students During Walking

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Abstract

This study was conducted to evaluate the effect of load carriage on electromyographic activity (EMG) of upper fibers of trapezius (UFT) of both right (RT) and left (LT) side in school students during walking. Thirty school students were assigned into one group, with mean age 13.66 ± 1.32 years. EMG was recorded from UFT (RT and LT) side under three conditions: First, with no pack while performing reference isometric contraction of UFT, second while carrying ergonomic double sided pack, lastly, while carrying ordinary bag style. The EMG of UFT (RT) (LT) while carrying ergonomic double sided pack was significantly less than while carrying ordinary pack with z-value –3.105 for RT UFT and –2.883 for LT UFT and p-value <0.05. It was concluded that the ergonomic double sided pack significantly decreased the EMG activity of UFT in comparison to ordinary backpack style.

Key Words: Load carriage – Upper fibers of trapezius – EMG

Introduction

THE issue of load carrying is regularly and widely discussed in the media, particularly before the start of the school year. There is a widely held belief that carrying of heavy loads, such as school backpacks, stresses adolescent spinal structures. As these structures are undergoing rapid growth, they are believed to be prone to structural damage [1,2].

Backpack is one of the most common designs used by children. It is the most popular style of schoolbag for both boys and girls. Abnormal postural changes due to the carrying of a backpack may induce round shoulder, forward head posture, changes in neck muscle activity and muscle fatigue [3,4].

Backpack carrying minimizes muscular requirements on both sides of the spine. But at the opposite side, two-strap backpack significantly increased forward leaning of the head and trunk and so other design is needed to decrease the undesired effects of bag carriage [5,6].

Carrying heavy objects at one side of the body shifts the center of gravity to that side bringing it dangerously near, or beyond, the base of support. When a load is carried on one side of the body the force on the opposite supporting hip during walking is much greater than when the load is distributed on both sides of body. This is true even when the total load carried on the two sides is twice as great as the carried on one side. So, when the weights carried on both sides of the body are equal, they balance each other and no adjustment of the body is required [7,8].

Anterior carriage was found to induce higher loading on the spine than posterior carriage. This might be associated with the increased activity of back muscles during anterior carriage and the creep effect on the intervertebral discs. Short-term putting a backpack anteriorly might be useful for temporarily relieving postural changes induced by posterior backpack carriage. However, anterior carriage is not recommended for prolonged load carriage [9].

One of the most common factors responsible for causing trapezius muscle strain is overuse of the muscle due to lifting heavy weights or carrying heavy backpacks. This can also cause soreness in shoulders and neck muscles [10].

Significant linear relationship was found between external load and EMG signal, prolonged repeated motions, with high force in unsuitable postures, result in incorrect habitual behaviors which in turn may lead to skeletal disorders. During sustained arm tasks, it has been largely indicated
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that UFT, a muscle with main function the stabilizing of shoulder girdle, presents EMG signs of fatigue [11].

**Material and Methods**

This study was conducted in Motion Analysis lab of the Faculty of Physical Therapy, Cairo University, from June 2012 to December 2012.

**Subjects:**

Thirty subjects were assigned in a single group. The study design was a (one group pre-post design).

**Exclusion criteria:**

- Any musculoskeletal disorders in upper, lower extremities, or spine.
- Any neurological illness which may impair their performance.
- Any disease or inflammation that makes the student can’t stand or walk independently.

**Methods:**

- **A- Evaluation tools:** Kinesiological EMG, Biopac, TEL 100-C, MP system is a computer-based data acquisition system. The MP unit takes incoming signals and converts them into digital signals that can be processed with the computer.

- **B- School backpack:** There are two bag styles were used by each student: The first was the ordinary backpack, which is used by most students. The second one was an ergonomically designed bag (modified double sided pack style). The bag total weight was 15% of body weight (BW) of each student in the ordinary bag and the same weight in the modified bag but it was equally distributed between the 2 sided bags of this style.

- **The ordinary backpack:**

  It is a double strapped backpack with dimension of 37x25x15cm. This is one of the ordinary backpack styles presented in the domestic market.

- **The modified double sided pack style criteria:**

  The pack has two sides each of the following dimensions (36x33x15) determined according to the anthropometric measures of a sample of the Egyptian students. This was determined according to the pilot study especially done for this study performed on students of preparatory schools, by taking the anthropometric measures of 100 students as a random sample from governmental preparatory schools. In the pilot study we measured the following measures: back width (the distance from acromion process to acromion process), trunk length (the distance from acromion process to iliac crest), height, body weight (kg) and bag weight (kg) for each student. After that the pack was designed according to these measures.

- **Electrodes’ placement:**

  - The active electrode was placed at lateral distance of approximately 25mm from the midpoint of the line connecting between the acromion and C7 [8].
  - The reference electrode was placed lateral to the active electrode, with inter-electrode distance approximately 20mm from center to center [5].
- The ground electrode was placed over the RT radial styloid process for RT UFT and over the LT radial styloid process for the LT UFT. The EMG signal was amplified and filtered by a bandpass with 30Hz and 500Hz; it is simultaneously digitized at 1kHz sampling rate and stored in the computer [5,12].

Procedure:

The students are first checked to face the inclusion criteria and have no one of the exclusion criteria. The skin under the electrodes’ placement were cleaned by alcohol. Each student was examined under three conditions: First, while carrying no pack (for measuring the reference isometric voluntary contraction). Second, while walking carrying the ordinary backpack with 15% of BW. Third, while walking with carrying the ergonomic double sided pack with 15% of BW, with rest ten minutes between each test for testing the RMS of EMG activities of the UFT muscle. Randomization was conducted by the operator through coin tossing to determine which bag style to start with firstly.

For the reference isometric voluntary contraction each student stood comfortably erect with the knees extended and the feet apart by approximately shoulder width. Then abduct his arms to 90 degree and to keep their head looking straight ahead. The operator starts EMG recording for five seconds [5].

EMG Normalization, The activity of the UFT was recorded while walking wearing each pack and while assuming the reference isometric voluntary contraction. The values of the RMS of the raw EMG data of UFT for each pack were normalized to reference isometric voluntary contraction through dividing the value of each bag score on the values of RMS of EMG of UFT (RT and LT) during carrying no pack (reference isometric voluntary contraction) [13].

The demographic data and the normalized EMG values for each bag style for the RT and LT side were collected for statistical analysis.

Results

Physical characteristics of the subjects:

In the present study, 30 students (19 male and 11 female) were participated in this study. The data in Table (1) represents Physical characteristics of subjects.

Normality test of the data:

Kolmogorov-Smirnove Z test showed the normalized value of RMS of EMG activities of RT and LT UFT during walking carrying the ordinary backpack and double sided pack which suggest non parametric tests i.e. Test distribution of the data was not normal as presented in Table (2) as the kolmogrove smirnov Z test has significant value for both conditions and in RT and LT sides.

<table>
<thead>
<tr>
<th>Table (1): Physical characteristics of subjects.</th>
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<tbody>
<tr>
<td>Items</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Weight</td>
</tr>
<tr>
<td>Height</td>
</tr>
<tr>
<td>Age</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table (2): Normality test for the different conditions.</th>
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<tbody>
<tr>
<td>Side</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Mean of normalized UFT EMG</td>
</tr>
<tr>
<td>SD</td>
</tr>
<tr>
<td>Kolmogrove smirnov z</td>
</tr>
<tr>
<td>p-value</td>
</tr>
</tbody>
</table>

*: Indicates significant test.

Statistical analysis:

Mann-Whitney test was used to test the significance of differences in the normalized RMS of EMG of RT UFT during walking, between carrying the ergonomic double sided pack and walking carrying the ordinary backpack. Median of the normalized RMS of RT and LT UFT during walking carrying the ergonomic double sided pack was presented in (Figs. 2,3). The Mean Rank of the normalized RMS of RT and LT UFT during walking carrying both types of packs as presented in Table (3).
Ordinary Modified

Fig. (3): The Bar of the median of the normalized RMS of LT UFT during walking carrying the ordinary backpack and the modified double sided pack.

There was significant difference in the students’ normalized RMS of EMG activities of both RT and LT UFT muscle while walking, between carrying the ergonomic modified double sided pack and walking carrying the ordinary backpack as presented in Table (3).

Table (3): Mean rank values and the median values of the normalized RMS of UFT (RT&LT) under two conditions by using Mann-Whitney test.

<table>
<thead>
<tr>
<th>Side</th>
<th>Group</th>
<th>n</th>
<th>Mean rank</th>
<th>Median</th>
<th>Mann-Whitney U</th>
<th>z value</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>Ordinary</td>
<td>30</td>
<td>1.314</td>
<td>37.5</td>
<td>240</td>
<td>-3.105</td>
<td>0.002*</td>
</tr>
<tr>
<td>LT</td>
<td>Double sided bag</td>
<td>30</td>
<td>1.113</td>
<td>23.5</td>
<td>225</td>
<td>-2.883</td>
<td>0.004*</td>
</tr>
</tbody>
</table>

*: Indicate significance of test.

Discussion

Recognition of the importance of studies involving children has led to reports on the effects of backpacks on postural changes and musculoskeletal impairments however, many of these studies have focused on segments of the back such as trunk forward lean, back muscle activity and back pain, neck and shoulder posture but there have been few reports on neck muscle activity whilst carrying a backpack [14-18].

This study was conducted to study influence of load carriage on myoelectrical activities of upper fibers of trapezius in school students during walking. The results of this study showed that the RMS of EMG activities of UFT was significantly less when walking carrying the ergonomic modified double sided pack than walking carrying the ordinary backpack at the two sides (RT and LT) of UFT muscle.

This result was supported by Kim [5] when tested the RMS of UFT EMG activities in forward head position during carrying three types of school packs (backpack, double bag and modified double) with 15% of body weight. They found that the RMS of EMG activity of the UFT was significantly higher while carrying the ordinary backpack than carrying the double pack and modified double pack (p < 0.05) plus the forward head distance and head angle was significantly increased for backpack. The double pack was consisted of a front pack and a backpack, both of the same type as that used in the backpack condition and each weighing 7.5% of body weight. While the modified double pack was especially made for that study and consisted of two types of packs; these were loaded so that the backpack and front pack weighed 10% and 5% of the body weight, respectively. The front pack was half the size of the backpack.

Piscione [19] found that through increasing a load up to 15 percent of body weight, the UFT EMG activities was increased; on the other hand, by increasing a load to 20 percent of body weight, it was found that UFT EMG activity decreased that by increasing backpack load, the strain exerted by backpack is transferred to lower parts of the trapezius and other body muscles, and this change of force exertion results in decreasing of UFT EMG activation.

In the present study the modified double sided pack style was used with 7.5% of BW on each side from T3 to the level of the greater trochanter. This led to more appropriate load distribution around the spine than when carrying ordinary backpack with 15% BW posterior to the trunk. So during walking carrying the modified double sided pack the load was distributed around the center of gravity (COG) of the body and muscle activities is less than during walking carrying the ordinary backpack [20].

Carrying loads bilaterally offers two specific advantages over unilateral load carrying. First, the bilateral load carrying produced less EMG activity than unilateral load. Second, the forces on both sides would be nearly equivalent due to the symmetry of the muscles on both sides and across both sides of the spine [21,22].

The load on the spine during carrying backpack I sinfluenced by the position of the load in relation to the center of motion in the spine, the weight and shape of the object. The shorter the lever arm of the force produced by the object weight, the lower the magnitude of the bending moment and
thus lowers the stresses on the spine and the muscles activities around it [20].

By reviewing the last facts, and how the ergonomic double sided bag decreased neck activity in school students we could reach to the fact that this style of load carriage can be recommended to school students to decrease their muscle activity and indirectly to decrease their postural malalignment. Thus we reject the null hypothesis that the different load carriage have no different effect on neck muscle activity.

Conclusion:

On the basis of the present data, it was possible to conclude that the modified double sided pack showed significantly less EMG activities of UFT (RT and LT) muscle compared with the ordinary backpack style. This may be attributed to that the modified double sided pack style decrease neck posture abnormality produced by the ordinary backpack.

Recommendations:

It is recommended that school students can use the modified double sided pack style as it decrease neck muscle activities, hence it may lessen expected neck problem as a result of using other packs. Further studies are needed to test the effect of different weights while using modified double sided pack on subject’s balance.

References


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