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The effect of common school bags on elementary school girls' trunk muscles electrical activity

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Abstract
Various methods for educational devices carrying, have different effects on student physical pain perception and muscles, skeletal, cardio vascular, respiratory and metabolism performances. So this research is conducted to review the school common bags carrying (hand bag, shoulder bag and backpack) on elementary school girl students body muscles electrical activity. This research subjects are selected (one school randomly) from hamedan city elementary grade girl students. Their body muscles electrical activities include: spine erectro muscle(ES), rectus abdominis (RA) bilateral, are recorded for each student by using EMG unit after carrying each one of these bags that weight about 10 percent of their body weight for 15 minutes on treedmile with a speed of 1/1 m/s and one minute standing. Finding showed that shoulder bag carrying result in dissimilar activities of left and right parts of two ES, RA muscles. Hand bag carrying results in increasing this dissimilarity in left and right parts of RA, ES muscles, so that EMG activity level in RA, ES muscles opposite direction increased significantly and it reduced significantly in the other direction. During backpack carrying EMG activity of RA muscle is reduced in a significant and dissimilar wayand it reduces in a significant and similar way in ES muscle. As result backpack carrying in comparison to the hand bag and shoulder bag lead to similar more and activity less.

Keywords: Electrical Activity, Student, School, Muscles

Introduction
People have to carry things in different ways in their daily lives. Correct way of carrying things should be attended to because inappropriate methods of carrying heavy things lead to physical complications and skeletal deformations. Children and adolescents do a wide variety of physical activities during their development of which carrying heavy school bags is one of the most important [2]. Until the end of puberty period at about age of 19, muscles, ligaments and bones of the students are still within the process of development and physical growth, and between the ages of 6 and 14 years they are extremely sensitive and prone to more injury [3].

Various bags available in the market encourage the students to use a variety of bags regardless of physical and muscular complications. Each of these bags is carried in a specific way. Different bags used in schools include backpack, front pack, backpack or knapsack double backpack or double case–front-back backpack, shoulder bag, hand bag and wheel bag. Figure1 shows examples of the types of bags used for carrying the school equipment. Studies have shown that different methods of carrying school equipment have different effects on the perception of physical pain and performance of musculoskeletal, cardiovascular, and respiratory systems, and body metabolism in the students. A decrease in strength of the involved muscles and early physical exhaustion in children [6,7], pain in various parts of the spine [8,9,10], increase of respiratory rate [11], increase in blood pressure and oxygen consumption when carrying a variety of school bags [12,13,14] prove this claim. Carrying loads in adults has been studied extensively; however, few studies have been done on carrying loads in children and adolescents, [2]. The few studies conducted on a variety of parameters of carrying loads in students including the position of the load [15], weight [16], walking speed [17], level of walking [18], walking on the stair [19], the design and appearance, [20], the design and weight [21] have been conducted from biomechanical and physiological aspects; however, few studies have compared different methods of carrying school equipment in terms of myoelectrical and pathological aspects. Hosseini et al. investigated the electeromyographical changes of the body muscles in elementary school boys, and concluded that backpack minimizes the imbalance of muscular activities and accordingly the pressure resulted from carrying school bags. They studied three kinds of common school bags (backpacks, handbags and shoulder bags) in elementary school boys. This study followed the model used by Hossain et al. (1388). However, the bags studied in this research include: backpack, shoulder bag and handbag which are used more commonly among the students [4].

There are differences in the study groups, muscles, and bags in these studies. Furthermore, there are few studies on elementary girl students, and girls' physical changes are different from boys' at this age. There are reports suggesting that the pain and pressure resulting from girls' school bags is more than those of boys, girls' physical activity especially in our country is much less than that of the boys due to the social, cultural and special limitations. Because girl students' health entails future health of our society, we intended to do a research on the effect of carrying school bags on EMG activity of trunk muscles in elementary girl students.

Method

The samples of this quasi-experimental applied study were selected using the multi-stage cluster random sampling through which respectively the schools, classes and students were randomly selected. First, out of a population of 21, 368 students of 9 to 11 years old, a random cluster size of 370 was selected, and their height, weight and BMI were measured in order to overcome the influence of anthropometric dimensions of the research. Subjects were selected so that they were matched for anthropometric characteristics [4]. (Mean height 143.7±3.67 cm, mean weight 37.17 ±1.91 kg). Out of this number, the sample (n= 20) was selected by random purposive sampling [inclusion criteria: general physical health, no musculoskeletal disorders], according to previous research conducted and the experts' comments [30]. All subjects were right-handed and had no history of participation in sports competitions during the school year. The condition of no bag [0% of body weight] was used as a control condition. To observe ethical principles, after informing the parents and school officials of the test method and application of the results, written consent was obtained from the school administrators, volunteer students and their parents to participate in the study. In the present study, students used the most common bags (handbag, shoulder and backpack). Examples of common school bags are presented in Figure 1. Bag weight in the present study was considered 10% of the body weight of the subjects because previous studies [4,21,11,31] recommended the same weight limit for student bags. Examples various bags are filled with books and other school supplies by the researchers.

Figure 1. Examples of handbag (right), shoulder bag (middle) and backpack (left)

Exercise protocol was defined as walking on a treadmill (150 - MED, COSMED, ROME, Italy) on a flat surface (no tilt) at the speed of 1.1 meter per second [32] for 15 min [4]. Each sample performed four tests: 1- walking with

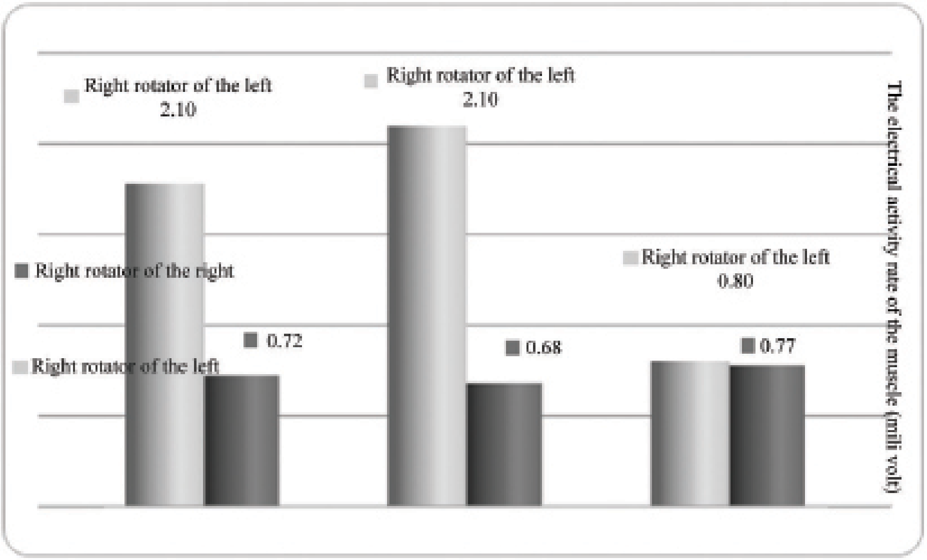

Figure 1 *EMG activity of the left and right ES muscle while carrying school bag*

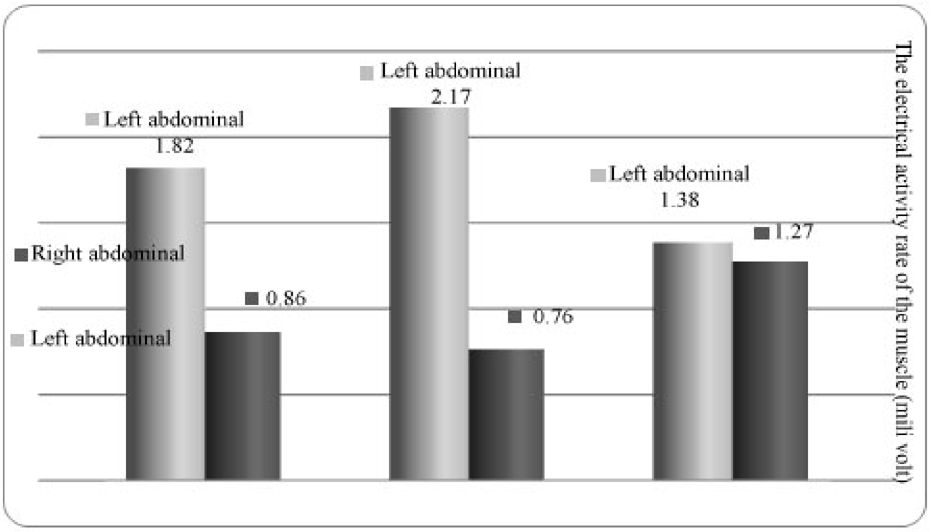

Figure 2 *EMG activity of the left and right RA muscle while carrying school bag*

no bag as a control-walking with backpack-walking and carrying a shoulder bag-walking and carrying handbag. Order of testing was randomized, and each student performed only one of the four tests per day. Immediately after 15 min of carrying each bag, the participants stood straight with feet as wide as shoulders (distance between the right and left acromion processes) [33], and EMG activity of trunk muscles were recorded for one minute [32]. After 15 minutes, walking without bag was measured for controlling and comparing. The muscles investigated in the present study include erector spinae (ES) and rectus abdominus (RA), respectively. First, to prevent occurrence of any noise or disturbance in variable measurement, hair in the designated areas was shaved and the skin in those 4 points (for each muscle on each side of the body, a point consistent with previous research) was cleaned with cotton and alcohol. The location of investigated muscles was determined by the researchers and marked. (Lumbar ES muscle: In the space between the L4/L5, 2-cm away from the midline on both the left and right sides or 3 cm away from spinous process of L3 [4]. RA muscle: The superior aspect of the anterior surface of sacrom, 2 cm away from the midline from both sides and 3 cm higher than umblicus) [4]. Then the electrodes were placed on the designated areas with electrolyte glue. The electrodes were made of mercury chloride and were placed on the abdominal muscles Direction of the electrodes was adjusted parallel to the muscle fibers. EMG activity of ES and RA muscles in both left and right sides of the body, immediately after the each test was recorded for one min in a static condition using 8-channel electromyography (ME300P8, Electronics LTD, Finland Muscle EMG Tester). Signals activated were normalized by the normalization reference. So the no bag status of each student (100) was considered as a reference and all other conditions were expressed as a percentage of the reference state. The signal booster built-in EMG set automatically amplified the recorded signals. The descriptive and inferential statistics were used to describe and analyze the data. Variables are described using descriptive statistics such as mean and standard deviation. To compare mean values of EMG between different tests, inferential statistics including analysis of variance (ANOVA) was used. Wherever a significant difference was observed between the different tests, the Bonferroni test was used to determine the significance level (significance level of 0.05). Also, in order to assess and compare the EMG activity between the left and right sides of each muscle and the consistency or lack of consistency between these two activities, the independent t-test was used.

Results

Participants' anthropometric characteristic measurements including the height, weight and BMI are shown in Table1.

Table1 *Participants' anthropometric characteristics*

Statistical index	Range	M±SD
Age (year)	9-11	9.75±0.71
Weight (kg)	34-40	37.17-1.91
Height (cm)	137-149	143.7±3.67
BMI ($^{kg}/_{m^2}$)	18.6±21.25	20.27±0.79

Comparing the mean of EMG activity of right and left RS at times of carrying different types of bags is given in Figure 1. The mean of EMG activity of the right and left RS during carrying a backpack were respectively 0.7775 and 0.8005 and the significance level of comparative results between the two sides was 0.682. The results showed that carrying a backpack did not cause a significant difference between the EMG activity of the left and right side of the ES muscle (P<0.682). Therefore, the activity of the right and left ES was symmetric at times of carrying a backpack. The mean of EMG activity of the right and left ES muscle during carrying a handbag were respectively 0.6810, 2.1015 and the significance level of comparative results between the two sides was P>0.001. So the activity of the right and left ES was asymmetric during carrying a handbag and a shoulder bag. The mean of EMG activity of the right and left ES during carrying a shoulder bag were respectively 0.3072, 1.7820 and the significance level of comparative results between the two sides was P>0.001. So the activity of the right and left ES was asymmetric during carrying a handbag and shoulder bag. While carrying a handbag and a shoulder bag on the right side of the body, level of EMG activity of the ES muscle on the left side of the muscle had a significant increase and on the right side of the muscle had a significant decrease (P=0.001). Figure 1. EMG activity of the left side and right side of the ES muscle at times of carrying school bags Comparison of the mean of EMG activity of the right and left RA muscle is shown in Figure 2. The mean EMG activity of the right and left RA muscle during carrying a backpack were respectively 1.2755, 1.3870, and the significance level of comparative results between the two sides was P=0.009.The results showed that there were significant differences between the EMG activity of the left and right sides of RA muscles during carrying a backpack (P=0.009). So the activity of the right and left RA was asymmetric during carrying a backpack and rate of the activity of the left was more than the right side of the muscle. The mean EMG activity of the right and left RA muscle during carrying a shoulder bag were respectively 0.7645 and 2.1720, and the significance level of comparative results between the two sides was P=0.001. So the activity of the right and left RA was asymmetric during carrying a shoulder bag. The results showed that during carrying a handbag and a shoulder bag on the right side of the body, level of EMG activity in the RA muscle was significantly increased on left side and significantly decreased on the right side (P = 0.001).

Figure 2. EMG activity of the left side and right side of the RA muscle during carrying school bags

Discussion

Carrying a backpack leads to a significant reduction in EMG activity in ES and RA muscles than other carrying other bags. This part of the research is consistent with the results of Motmans et al. [4], Hosseini et al. [6]. They also reported the reduction of muscle activity during carrying a backpack. It can be attributed to the position of the bag on the back and near the center of the body rather than a shoulder bag and handbag. The lower is the distance between the load and the body's center of gravity, the less EMG activity of trunk muscles is expected [6]. During carrying a backpack, this distance is less than that during carrying a handbag or a shoulder bag. However, the ES muscle activity of the left and right parts reduces symmetrically and that of the left and right parts of RA muscle decreased asymmetrically. This finding is consistent with previous results [6,34,35]. They also observed asymmetry between the activity of left and right parts of RA muscle. However, they reported the activity of right part more than that of the left part, while in the present research the activity of the left part of the RA muscle was more than that of the right part. This may be due to the dominance of the dominant (right) hand. Given that the subjects were all right-handed and performed all their activities with their right side of the body.

In the present study, the asymmetry of the EMG activity of the left and right parts may be due to the possible influence of the dominant (right) hand, lateral leaning of the body to the right, stretching of body's left side muscles and struggling for restoring body to the opposite side. In a study by Hosseini et al. (2001), the activity of left and right parts of RA muscle were symmetric [4]. Comparing the pressure on the sole in the state of standing and walking with carrying a variety of bags, Kung et al. concluded that the backpack group regardless of the bag weight showed a significant difference between right and left part in the state of standing and walking [37]. In the present study, carrying a shoulder bag led to unequal and asymmetric EMG activity in the right and left parts of both anterior and posterior muscles. In other words, carrying this bag on one side of the body led to a significant decrease in EMG activity in that part of the RA and ES muscles and a significant increase in EMG activity in the opposite part of the RA and ES muscles. The results of this study are consistent with results obtained by Hosseini and Mvtmnz [4,6]. They found that carrying a shoulder bag on the right side of the body led to an increase in EMG activity in the left and a decrease in EMG activity in the right. However, they had predicted a far greater increase in trunk muscle activity when carrying a shoulder bag rather than backpack and front pack because the distance between the load position and the body center of gravity was greater in the shoulder bags. These changes can be justified in that carrying a shoulder bag on one side of the body leads to lateral leaning of the distal part of the body to that side. This leads to pressure on the opposite side muscles (muscle strain) and their efforts to prevent the lateral side flexion in the carrier side of the bag [36] whose final outcome may be imbalanced gait biomechanics [36,38]. Biomechanical changes in gait may lead to imbalance pressure on the muscles of both sides of the body. Moreover, longer distance between the load and body's center of gravity causes greater EMG activity of trunk muscles. [6] This distance is much greater when carrying a shoulder bag than when carrying a backpack.

Pasko et al. in 1997, Huang et al. in 2011, the Institute of Work and Health of Bern University for America in their research found that carrying a shoulder bag and backpack caused the shoulder to move up and the shoulder to deviate lateral deviation of the backbone. And most of postural changes of adolescence is when students carry school bags with one strap and or use a sport sack or backpacks with one strap [36,39]. Gong et al in 2010 after comparison of plantar pressure in the mode of stand and walk, while carrying different kinds of bags, have found a significant difference in plantar pressure of the left and right sides with the weight of 5 kg while carrying KULEYE SHANEYI, and understood that occurrence of muscular- skeleton disorder when walking with shoulder carrying backpacks heavier than 5 Kg was due to excessive use of the muscles of the opposite side [37]. Thus, the disparate activities of muscles when carrying a shoulder bag with the resulting changes in the long term may be harmful.

In this research, carrying handbag led to the maximum electrical activity in all the studied muscles and the greatest difference between the activity of the muscles of the right and left ES, RA, so that the EMG activity on the opposite side of the bag in the ES and RA muscles increased significantly and in the concordant side it decreased significantly. The results are consistent with the results of Hossaini et al. [4]. They also have observed the highest difference between the right and left ES and RA muscles when carrying handbag. On the cause of these changes, it can be said that similar to a shoulder bag, carrying hand bags as well leads to lateral flexion of the trunk, but with more intensity. These changes lead to strain on muscles on the opposite side of the bag [36]. Also the distance between the bag location and the body center of gravity in the state of carrying handbag is at the maximum possible distance. Mutemnz et al. have reported that more distance causes more EMG activity of trunk muscles [6]. Thus, the highest EMG activity in ES and RA muscles during carrying a bag is reasonable.

Conclusion

Generally, the results of the present study showed that backpack, in comparison to the other bags, minimized the muscle pressure created as the result of carrying school supplies by the students because carrying this bag did not disturb the consistency and proportionality between the activity of the muscles of the left and right parts of the spine. After that, shoulder bag and handbag respectively apply the largest muscle tension on the body. And asymmetry of left and right muscle activity during carrying the bag may lead to early fatigue of students and may interfere in rhythm and the process of walking.

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Contributions

Study design: AEA

Data collection and analysis: SHH, SMM

Manuscript preparation: SMM, NKHY

Conflict of Interest

"The authors declare that they have no competing interests."

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