Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
Article DOI: 10.21474/IJAR01/3944
DOI URL: http://dx.doi.org/10.21474/IJAR01/3944
ISSN NO. 2320-5407

*RESEARCH ARTICLE*

# THE CHARACTERISTICS AND IMPACT OF SCHOOL BAG ON PRIMARY AND PREPARATORY SCHOOL STUDENTS OF ALEXANDRIA GOVERNORATE

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## *Manuscript Info*

***Manuscript History***

Received: 02 February 2017
Final Accepted: 16 March 2017
Published: April 2017

***Key words:-***
Back problems, School bag, Students.

## *Abstract*

**Background:** The effects that backpacks can potentially have on the body ranges from no noticeable change in upright posture, postural stability and/or pain to the assumption of a position of trunk flexion accompanied by pain and postural instability. External forces, such as heavy backpack loads, may affect the development of normal skeletal alignment, resulting in musculoskeletal complaints, vertebral abnormalities and compensatory strategies that alter postures and structures.

**Objectives**: To evaluate the different parameters of school bag and the percentage of the bag weight in relation to the student's body weight, perception of stability, subjective musculoskeletal pain, impact on medical utilization and lost school time.

**Methods**: The study was conducted in primary and preparatory schools of Alexandria Governorate. One thousand and twenty nine students were chosen randomly based on educational zones, type of school, and sex. An interview questionnaire was used to collect data about the characteristics, symptoms and the description of the students' bags.

**Results:** Almost half of students carried school bags that weigh ≥ 10% of their body weight and the most significant predictors were school type and student's age. Also, students who had poor believes about the school bag use, were more likely to have relative school bag weight ≥ 10%. Students belonging to families with sufficient income, positive family history of back pain, students' BMI <19 and had better knowledge about school bag carriage were more likely to report moderate to severe musculoskeletal pain. Falling or feeling of fall while carrying the bag, were significantly more represented among those with relative heavy school bag.



## Introduction

The effects that backpacks can potentially have on the body are numerous. Ranging from no noticeable change in upright posture, postural stability and/or pain to the assumption of a position of trunk flexion accompanied by pain

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and postural instability, there is growing concern regarding health effects due to backpack wear.[1]

Serious concerns about the harmful effects of heavy backpacks are growing. The peak rate of growth occurs during childhood and puberty. The growth of the skeletal system ceases around 16 years of age for females and 18 years for males. However secondary ossification of vertebrae is not complete until the mid-twenties.[2] Therefore, the tissues of the human body are sensitive and responsive to tension, compression, shear and torsion of the loads that are applied to them.[3] External forces, such as heavy backpack loads, may affect the development of normal skeletal alignment,[4] resulting in musculoskeletal complaints, vertebral abnormalities and compensatory strategies that alter postures and structures.[4,5] Since a history of back pain in childhood is a strong predictor of having musculoskeletal discomfort and back pain as an adult, development of back pain due to backpack use is of prognostic concern.[6] Studies from different countries showed that heavy backpack carried by students is one of the factors that might cause disturbance in the maturing musculoskeletal system.[7]

**Aim**

To study the characteristics of school bag and its impact on students' health concerning the percentage of the bag weight in relation to the student's body weight, the methods of carriage, and presence or absence of the desirable bag features, the association between relative school bag weight and perception of stability of students, subjective musculoskeletal pain, pain site, as well as its impact on medical utilization and lost school time.

## Subjects and Methods

**Study setting:** Primary and preparatory schools (public and private) of Alexandria Governorate.

**Target population**

1. Fourth, fifth, and sixth grades primary school students (boys and girls).
2. All grades of preparatory school students (boys and girls).

**Exclusion criteria**

1. History of any neuromuscular disorders and/or chronic diseases associated with pain as rheumatic, blood, metabolic, hereditary diseases or trauma.
2. History of vestibular or balance problems.

**Sampling Design**

**Sample size**

Using Epi Info™ 7 version (Atlanta, Georgia, USA),[8] a minimum required sample was calculated assuming a prevalence of 50% of school bags weighing more than 10% of students' weight. The calculated sample size at 95% confidence level, 3.5% precision and 20% anticipated non-response, was found to be 1000 students.

**Sample selection**

A multistage stratified random sample was conducted. Stratification was based on educational zones, type of school, and sex. Proportional allocation method was used to allocate sample size over strata.

**For conduction of the study the following tools and techniques were used**

A structured interview questionnaire to collect data about socio-demographic characteristics of the students, leisure activities and school achievement of the students, family characteristics of students, musculoskeletal complaints related to school bag carriage by students, students' subjective perception of stability during carrying bag, students' knowledge about school bag characteristics, students' believes related to school bag use, and self-reported students' practices related to school bag use.

- Observation of school bag and students' practices to collect data related to school bag characteristics, school bag method of use, and observed signs.
- Also weight, height, back length, bi-acromial width, bi-iliac width. Weight, height, and width of school bag were measured. BMI, relative bag weight (%), and relative bag area (%) were calculated.

## Results

Our results showed that the mean BMI (±SD) of students was 20.17± 3.07 kg/m2. The mean bag's weight as a percentage of student's body weight was 9.82±8.21% and that of the bag's area to the student's trunk area was 146.38±46.79%. The anthropometric measurements of the students and the dimensions of their school bags are demonstrated in (Table 1). Forty four % of students carried school bags that weigh more than 10% of their body weight. (Figure 1) is a graphical representation of distribution of bag weight as a percentage of student's body weight. The prevalence and determinants of carrying a school bag > 10% of body weight were demonstrated in (Table 2). It was found that the mean age of students in fourth, fifth, sixth primary, first, second, and third preparatory were 9.8±0.6, 10.7±0.6, 11.8±0.6, 12.9±0.6, 13.8±0.7 and 14.8±0.6 respectively. Males and females had almost similar age in each grade. Males and females were also comparable in the mean BMI. As regard the relative bag weight, the mean relative bag weight of students was maximum at the fourth grade (11.10%±2.75%) and decreased significantly and steadily to 10.10%±2.42% in the fifth grade, 9.10%±2.54% in the sixth grades, 7.95%±2.41% in the first preparatory grade, 6.76%±2.29% in the second preparatory and 5.47%±1.80% in the third preparatory. No significant difference was found between males and females in the mean relative school bag weight except in the first (7.49%±2.60% vs 8.36%±2.17% respectively).and third preparatory (4.96%±1.79% vs 5.88%±1.74% respectively) grades where girls had significantly higher mean relative bag weight than boys.

We found that 18.5%, 63.2%, 52.6% of students having relative school bag weight more than 10% had neck, shoulder, and back pains respectively, compared to 11.0%, 45.2%, 34.8% respectively of students having relative school bag weight 10% or less. These differences were found to be statistically significant ($p<0.05$).

Observation of students and their bags (Table 3) shows that in 15.1% of cases there was only one shoulder built, while in 22.6% of cases, neither the shoulder belt nor the bag back was padded. The number of partitions was one or two in 44.7% of cases and almost all cases had neither pressure belt inside bag nor waist belt (98%). Most of the students' backpacks (80.7%) were without wheels.

Concerning the backpack's method of use, 22.8% of students carried the bag on one shoulder. Almost all students (99%) didn't put material on the bag's back or carry additional bags but they didn't use middle built. Books were put inside bag without order by 31.8% of students. Almost all (99.8%, 99.7%) of the students incorrectly pull up or put down the bag, 35.3% of students had difficulty in bag carriage and 16.4% of students encountered difficult walking while carrying the backpack. The place of bag on student's pack was not suitable in 53.3% of cases.

There was observed redness seen in 3.1% of the students. More than one third of the students (39.9%) had straight back, and 60.1% their backs weren't straight.

In the current study, the results showed that the impact of knowledge, beliefs, and practices on site of pain, neck and back pains were significantly higher in students having poor beliefs related to backpack use (23.4% and 55.0% respectively, $p<0.05$), while shoulder pain was significantly higher in students having good knowledge about school bag characteristics ($p<0.05$) and in students with poor self-reported practices related to school bag use ($p<0.05$).

As regards observed practices of students, as only 3 students demonstrated good practice so, the fair and good categories were merged. There was always higher prevalence of pain on the three sites among students with poor practice than those with fair to good practice but it was only significant with neck pain (19% of students with poor practice reported neck pain versus 12.1% of students with fair to good practice) (Table 4).

(Table 5) showed that 6% of the students had past history of back pain. When asked about last month, 73.8% reported that they sometimes feel back pain due to carrying school bag, 5.5% reported usually feel back pain on carrying school bag and 20.7% were non pain reporters.

Of the 816 pain reporters, 18% indicated pain in the neck region, 67% in the shoulders, and 53.8% in the back. About 83% of pain reporters had pain 25% or more of time during bag carriage and 17.4% for less than 25% of time. Concerning the degree of pain, 95.2% of pain reporters had insignificant pain, while 3.1% of them had significant pain not affecting usual performance, and 1.7% had significant pain affecting usual performance. In ninety-four percent of cases, pain disappeared after taking bag off and in 6% of cases it was persistent.

As regards the impact of pain, the table shows that 4.3% of the students had lost school time, 4.6% had lost sports time, and 2.7% were unable to do other daily activities due to their backpack related pain. About 3% of the students went to the physician because of pain and 5.6% had had numbness of either arms or hands or both during carrying the bag.

Students who experienced falling at least once during bag carriage were significantly more represented among those with relative school bag weight >10% of their body weight (P<0.05). Feeling of fall twice or more while carrying the bag, was significantly more prevalent among those with relative school bag weight >10% (P<0.05) (Table 6). The table also showed that the percentage feeling imbalance on doing activities while carrying bag were higher among students had relative school bag weight more than 10% than those carrying backpack 10% or less of their body weight whether they said few times (64.8% versus 48.0%) or sometimes (21.4% versus 13.4%).

**Table 1:-** Anthropometric measurements of students and measurements of school bag.

| Measurements | Mean | SD |
|---|---|---|
| **BMI kg./height (m)$^2$** | 20.17 | 3.07 |
| **Bag weight/student body weight (%)** | 9.82 | 8.21 |
| **Bag area/student trunk area (%)** | 146.38 | 46.79 |

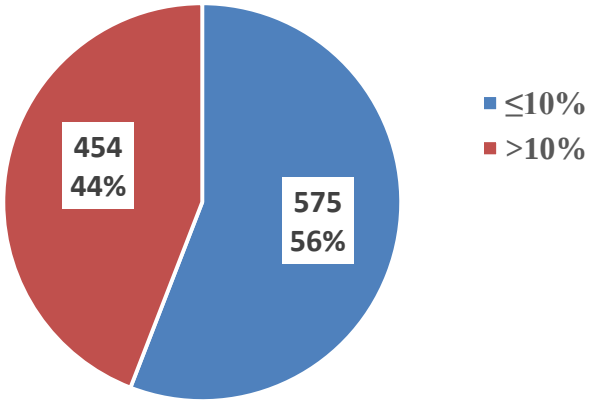


**Figure 1:-** Bag weight as a percentage of student body weight

**Table 2:-** Prevalence and determinants of carrying a school bag >10% of body weight.

| Year | | No. surveyed | Age (Years) | | BMI kg./height (m)$^2$ | | Relative bag weight (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean | SD | Mean | SD | Mean | SD |
| **4th grade** | Male | 137 | 9.78 | .62 | 18.65 | 2.60 | 11.01 | 2.61 |
| | Female | 126 | 9.71 | .66 | 19.13 | 2.89 | 11.19 | 2.90 |
| | Total | 263 | 9.75 | .64 | 18.88 | 2.75 | 11.10 | 2.75 |
| | **P(t)** | | 0.383 | | 0.161 | | 0.596 | |
| **5th grade** | Male | 119 | 10.77 | .64 | 19.81 | 2.96 | 10.17 | 2.37 |
| | Female | 133 | 10.71 | .58 | 19.63 | 2.65 | 10.04 | 2.47 |
| | Total | 252 | 10.74 | .61 | 19.72 | 2.80 | 10.10 | 2.42 |
| | **P(t)** | | 0.392 | | 0.603 | | 0.663 | |
| **6th grade** | Male | 122 | 11.93 | .57 | 20.07 | 2.93 | 9.08 | 2.60 |
| | Female | 108 | 11.76 | .61 | 20.72 | 3.50 | 9.13 | 2.50 |
| | Total | 230 | 11.85 | .60 | 20.38 | 3.22 | 9.10 | 2.54 |
| | **P(t)** | | 0.034* | | 0.127 | | 0.878 | |
| **1st preparatory** | Male | 59 | 13.03 | .59 | 20.67 | 2.43 | 7.49 | 2.60 |
| | Female | 67 | 12.76 | .63 | 20.32 | 2.19 | 8.36 | 2.17 |
| | Total | 126 | 12.89 | .62 | 20.48 | 2.30 | 7.95 | 2.41 |
| | **P(t)** | | 0.013* | | 0.399 | | 0.042* | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2nd preparatory** | Male | 56 | 13.82 | .66 | 21.64 | 3.34 | 6.42 | 2.19 |
| | Female | 41 | 13.73 | .63 | 22.58 | 2.69 | 7.23 | 2.37 |
| | Total | 97 | 13.78 | .65 | 22.03 | 3.10 | 6.76 | 2.29 |
| | **P(t)** | | 0.504 | | 0.142 | | 0.086 | |
| **3rd preparatory** | Male | 27 | 14.96 | .59 | 23.36 | 1.79 | 4.96 | 1.79 |
| | Female | 34 | 14.71 | .63 | 23.27 | 1.82 | 5.88 | 1.74 |
| | Total | 61 | 14.82 | .62 | 23.31 | 1.79 | 5.47 | 1.80 |
| | **P(t)** | | 0.108 | | 0.850 | | 0.048* | |
| **Comparison by grade** | **P(F)** | | 0.001* | | 0.001* | | 0.001* | |
| **All sample** | Male | 520 | 11.59 | 1.67 | 20.05 | 3.03 | 9.16 | 3.04 |
| | Female | 509 | 11.47 | 1.63 | 20.31 | 3.06 | 9.41 | 2.91 |
| | Total | 1029 | 11.53 | 1.65 | 20.18 | 3.05 | 9.28 | 2.98 |
| | **P(t)** | | 0.245 | | 0.167 | | 0.180 | |

**P(t):** Student t-test **P(F)**: One-way ANOVA *P<0.05 (significant)

**Table 3:** Distribution of the sample according to observation of school bag and students' practices related to it

| **Observation items** | | **No.** | **%** |
|---|---|---|---|
| ***School bag characteristics*** | | | |
| **No. of shoulder belts** | 1 | 155 | 15.1 |
| | 2 | 874 | 84.9 |
| **Shoulder belt is padded** | No | 233 | 22.6 |
| | Yes | 796 | 77.4 |
| **Bag's back is padded** | No | 233 | 22.6 |
| | Yes | 796 | 77.4 |
| **Bag's partitions** | 1 | 110 | 10.7 |
| | 2 | 350 | 34.0 |
| | 3+ | 569 | 55.3 |
| **Pressure belt inside bag** | No | 1009 | 98.1 |
| | Yes | 20 | 1.9 |
| **Waist belt** | No | 1010 | 98.2 |
| | Yes | 19 | 1.8 |
| **Wheels** | No | 830 | 80.7 |
| | Yes | 199 | 19.3 |
| ***School bag method of use*** | | | |
| **Method of bag carriage** | On one shoulder | 235 | 22.8 |
| | Both shoulders | 794 | 77.2 |
| **Putting material on bag's back** | No | 1025 | 99.6 |
| | Yes | 4 | 0.4 |
| **Using waist belt** | No | 1026 | 99.7 |
| | Yes | 3 | 0.3 |
| **Carrying additional bags** | No | 1020 | 99.1 |
| | Yes | 9 | 0.9 |
| **Books' order** | Ordered | 702 | 68.2 |
| | Without order | 327 | 31.8 |
| **Method of pulling up bag** | Correct | 2 | 0.2 |
| | Incorrect | 1027 | 99.8 |
| **Method of putting down bag** | Correct | 3 | 0.3 |
| | Incorrect | 1026 | 99.7 |
| **Place of bag on student's back** | Suitable | 481 | 46.7 |
| | Not suitable | 548 | 53.3 |
| **Find difficulty in bag carriage** | No | 666 | 64.7 |
| | Yes | 363 | 35.3 |

| Observation items | | No. | % |
|---|---|---|---|
| **Find difficulty walking with bag** | No | 860 | 83.6 |
| | Yes | 169 | 16.4 |
| ***Observed signs*** | | | |
| **Redness on arms or hands** | No | 997 | 96.9 |
| | Yes | 32 | 3.1 |
| **Student's back while carrying bag** | Straight | 411 | 39.9 |
| | Not | 618 | 60.1 |

**Table 4:** Impact of relative school bag weight, knowledge, beliefs and practices of students on site of musculoskeletal pain related to schoolbag

| | | No. surveyed | Neck | | Shoulder | | Back | |
|---|---|---|---|---|---|---|---|---|
| | | | No | % | No | % | No | % |
| **Relative bag weight (%)** | <10 | 575 | 63 | 11.0 | 260 | 45.2 | 200 | 34.8 |
| | >10 | 454 | 84 | 18.5 | 287 | 63.2 | 239 | 52.6 |
| | **P** | | 0.001* | | 0.001* | | 0.001* | |
| **Knowledge** | Poor | 36 | 3 | 8.3 | 14 | 38.9 | 20 | 55.6 |
| | Fair | 382 | 45 | 11.8 | 188 | 49.2 | 158 | 41.4 |
| | Good | 611 | 99 | 16.2 | 345 | 56.5 | 261 | 42.7 |
| | **P** | | 0.089 | | 0.018* | | 0.258 | |
| **Beliefs** | Poor | 111 | 26 | 23.4 | 62 | 55.9 | 61 | 55.0 |
| | Fair | 577 | 74 | 12.8 | 308 | 53.4 | 242 | 41.9 |
| | Good | 341 | 47 | 13.8 | 177 | 51.9 | 136 | 39.9 |
| | **P** | | 0.013* | | 0.759 | | 0.018* | |
| **Self-reported Practices** | Poor | 49 | 11 | 22.9 | 32 | 66.7 | 23 | 47.9 |
| | Fair | 612 | 93 | 15.2 | 303 | 49.5 | 255 | 41.7 |
| | Good | 368 | 43 | 11.7 | 212 | 57.5 | 161 | 43.6 |
| | **P** | | 0.066 | | 0.009* | | 0.628 | |
| **Practices by observation** | Poor | 321 | 61 | 19.0 | 182 | 56.7 | 142 | 44.2 |
| | Fair/Good ¥ | 708 | 86 | 12.1 | 365 | 51.6 | 297 | 41.9 |
| | **P** | | 0.004* | | 0.126 | | 0.492 | |

P: Pearson $X^2$ test ¥ Only 3 students demonstrated good practice
* P < 0.05 (significant)

**Table 5:-** Distribution of the students according to musculoskeletal disorders related to school bag carriage and its impact.

| Musculoskeletal disorders | | No. | % |
|---|---|---|---|
| **Previous history of back pain** | No | 967 | 94.0 |
| | Yes | 62 | 6.0 |
| **Back pain due to carrying school bag during last month** | No | 213 | 20.7 |
| | Sometimes | 759 | 73.8 |
| | Usually | 57 | 5.5 |
| **Site of pain §¥** | Neck | 147 | 18.0 |
| | Shoulders | 547 | 67.0 |
| | Back | 439 | 53.8 |
| **Duration of pain during bag carriage ¥** | > 25% of time | 142 | 17.4 |
| | ≤ 25% of the time | 674 | 82.6 |
| **Degree of pain ¥** | Insignificant | 777 | 95.2 |
| | Significant/not affecting usual performance | 25 | 3.1 |
| | Significant/affecting usual performance | 14 | 1.7 |
| **Pain disappear after taking bag off ¥** | No | 49 | 6.0 |
| | Yes | 767 | 94.0 |
| **Absence from school due to pain ¥** | No | 781 | 95.7 |

| | | | |
|---|---|---|---|
| | Yes | 35 | 4.3 |
| **Absent from sporting activity due to pain $** | No | 381 | 95.5 |
| | Yes | 18 | 4.5 |
| **Pain prevents doing activities of daily life ¥** | No | 794 | 97.3 |
| | Yes | 22 | 2.7 |
| **Went to physician for pain ¥** | No | 795 | 97.4 |
| | Yes | 21 | 2.6 |
| **Numbness of arm/hands during carrying bag** | No | 971 | 94.4 |
| | Yes | 58 | 5.6 |

N = 1029
¥ n = 816
§ Percent do not add to 100% due to multiple response
$ n = 399 (Those who practice exercise and have pain)

**Table 6:** Relative school bag weight and its impact on perceived instability.

| | | ≤10% (n = 575) | | >10% (n = 454) | | $X^2$ | P |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | | |
| **Previous fall during bag carriage** | No | 491 | 85.4 | 329 | 72.5 | 27.46 | <0.001* |
| | Yes once | 35 | 6.1 | 61 | 13.4 | | |
| | Yes twice | 29 | 5.0 | 41 | 9.0 | | |
| | Yes 3 or more times | 20 | 3.5 | 23 | 5.1 | | |
| **Feeling of fall while carrying bag** | No | 351 | 61.0 | 144 | 31.7 | 90.41 | <0.001* |
| | Yes once | 17 | 3.0 | 13 | 2.9 | | |
| | Yes twice | 43 | 7.5 | 67 | 14.8 | | |
| | Yes 3 or more times | 164 | 28.5 | 230 | 50.7 | | |
| **Feeling imbalance on doing activities while carrying bag** | No | 234 | 40.7 | 67 | 14.8 | 85.13 | <0.001* |
| | Few times | 276 | 48.0 | 294 | 64.8 | | |
| | Several times | 77 | 13.4 | 97 | 21.4 | | |

*P<0.05(significant)

## Discussion

There is growing concern regarding both immediate and more chronic health effects due to backpack use.[9] While studies into the chronic health effects would appear to require longitudinal tracking of backpack wear, assessment of the short term changes is more feasible and can represent the presence of acute alterations that should be considered when establishing guidelines for backpack use. The aim of the present study was to study the school bag problem among school students in Alexandria. According to our research this is one of the first studies in this scope in Alexandria. Relative backpack weight percentage carried by students can be considered as a key factor of safety and significant musculoskeletal complaints of school children.

The current study showed that the mean bag's weight, as a percentage of student's body weight was 9.82±8.21%, which is within the recommended limit of less than 10% of BW. However 44% of students carried school bag that weighs more than 10% of their body weight. This was consistent with the study of Young et al. who reported the mean backpack weight percentage of BW was 9.6% in age between 7 and 14 years old.[10] Some studies found lower percentages 8.2%, 8.84 %,[11,12] while others found percentages more than 10% and less than 15%.[13-15] Considerable higher percentages of relative backpack weight were reported by Ren et al. (17%),[16] Farhood (18%),[17] Ibrahim (21%).[18] The difference may be related to the use of different population sizes, setting, methods, and various confounding factors measured in each study which limits the opportunities for direct comparison. The wide range of the mean percent of backpacks weight to the students' BW carried by the students might be explained by the fact that there is differences between schools, grades or school students brings more books to school each day than others. Some empty schoolbags may have been heavier than others, but empty schoolbags were not measured in the current study.

In the present study the mean relative bag weight of students was maximum at the fourth grade (11.10% ± 2.75%) and decreased significantly and steadily with increasing grade. Other studies had similar findings.[19-21,14] Skaggs et al. found that younger children had a greater ratio of backpack weight to BW and were more likely to have back pain.[21] Also Pau et al. reported that younger elementary school students carried loads representing a greater percentage of their body weights.[22] The present study showed that younger students are more likely to carry school bags heavier than 10% of their body weight. This is a critical finding as primary school students, in spite of their smaller height and weight, carry heavier school bags than preparatory school students. This is because teachers and students do not follow a specific schedule bringing most of the books every day in addition to the lack of experience and inability of this age group in deciding the necessary books and supplies to take to school. Other reason for heaviness of bags is related to water bottles, hats, jackets that all the students carry.

Concerning the backpack's method of use in the present study, more than three quarter of the students carried the bag on both shoulders. Findings of this study are consistent with most of the studies whom found that the majority of their samples carry their backpack on both shoulders, and backpacks with one strap cause asymmetry of the spine and causing pain in shoulders, neck and back in children.[13,23,24] Almost all students of the present study didn't put material on the bag's back or carry additional bags, also they didn't use middle built. Books were put inside bag without order by 31.8% of students. Pack the heaviest items in the child bag closest to the child's back is a correct use of backpack but if the heaviest items are packed further away, this throws out the child's center of gravity and causes unnecessary back strain.[25] A vertically arranged backpack load, using slanting partitions within the main compartment, was found to result in significantly less shoulder, neck, lower back, and overall perceived discomfort. A vertically arranged load would result in less torque on the shoulders due to the load center of mass being horizontally closer to the person's center of mass.[26] Almost all of the students in the present study incorrectly pull up or put down the bag. Some general rules for lifting are widely agreed upon, such as keeping the load close to the body and squat lifting. Twisting while lifting must be avoided because torsion combined with loading can damage the facet joints as well as the intervertebral disks.[27]

In addition to the weight of the load, factors such as load placement may influence physical stress and energy cost. It has been suggested that loads should be located centrally on the trunk and not carried asymmetrically, as in handbag, shoulder bag or backpack carried unilaterally.[28] Furthermore, in relation to the sagittal plane, the load needs to be carried close to the center of mass of the body, thus minimizing the displacement created by the load.[29]

Brackley et al. stated that the low load placement in the backpack produced fewer changes in cranio-vertebral angle from the initial standing baseline measure than the high and mid placements and there were fewer changes in lumbar lordosis in the low load placement. They found that carrying backpack centered at the level of third lumbar vertebra (low on the back) associated with least postural displacement. [30] Elevation of the center of mass in high load placement will maximize postural displacement and attenuate imbalance, meaning the body requires more energy to maintain equilibrium. In addition, it has been reported high load placement led to a greater trunk inclination angle.[31] Regarding the impact of pain, the present study showed that only small percent of the students had lost school time, had lost sports time, and were unable to do other daily activities due to their backpack related pain. This is consistent with finding that high percentage of students of students recorded no/mild musculoskeletal pain related to school bag and only 1.3% recorded sever pain. In consistence with our result, Moore's et al. found that students who reported pain lost school time because of their condition. In addition, 9.2% and 6.9% were not able to participate in the entire duration of school sports and physical education class, respectively.[32]
The present study showed that the prevalence of moderate to severe musculoskeletal pain was significantly higher among males compared to females. This is in disagreement with certain previous studies on gender differences in general pain incidence [33] and in agreement with others.[34] These findings suggest that individual factors including age, gender and body composition need to be considered as potential confounders in musculoskeletal complaints among school children.

## Conclusion

Almost half of students carried school bags that weigh more than 10% of their body weight and the most significant predictors were school type and student's age. The pain that the students felt in back, shoulder and neck can be caused by postural changes during wearing the backpack, the postural changes will cause increase in muscles activity that leads to muscles strain and eventually muscles soreness. Changes in trunk posture are known to affect the relative orientation of the spine and the stress distribution within the spine. These changes in trunk posture may lead to strain on the body and subsequent muscle fatigue and micro trauma, potentially culminating in

musculoskeletal disorders. Increasing backpack loads significantly compressed lumbar disc heights and significantly increased lumbar asymmetry which in part, may be responsible for a significant amount of back pain in children and in adulthood later on.

## Recommendations

Modifying the risk factors associated with back pain is advocated as the most important prevention strategy in school children and adolescents. We recommend school administrators to provide children with storage facilities (lockers) for materials not needed on a daily basis. Backpack safety and injury prevention educational materials can be integrated into the physical education or health education curriculum. Utilize a variety of venues to share information periodically on backpack safety with parents, students, and staff such as e-school newsletters, and school webpage. Print backpack safety tips on the back of the school supply lists that are distributed to families.

**Conflicts of interest**

The authors declare no conflicts of interest.

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