School backpack

How much load do Saudi school boys carry on their shoulders?

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ABSTRACT

Objectives: To investigate the percentage of body weight represented by school backpacks, to determine the dimensions of school packs, and to identify the methods of carrying book bags by elementary school boys.

Methods: A cross-sectional study, using a multistage random sampling technique, was conducted during the Spring of 2005. Six elementary schools from Riyadh were included involving 702 Saudi boys in grade 1-6. Measures included body mass, height, biacromial and bi-iliac breadths, triceps and subscapular skinfolds, calculated fat percentage, school bag weight and dimensions. Students were also asked to respond to questions related to how they travel to and from school, how they carry the bag, and if they have pain due to bag carriage.

Results: Body fat percentage increased from 14.2% in the first graders to 24.6% in the sixth graders. The increase in body dimensions, however, was less than the increase in the fat percentage. School bag averaged 3.2 kg in absolute weight and 10.7% relative to student's body mass. Nearly 50% of the sample carried backpacks weighing more than 10% of their weight. Bag surface area averaged 1.05 m^2 while the ratio of bag surface area to student's trunk area ranged from 129% in the first graders to 81% in the sixth graders. Approximately 29% of the students walk to and from school. More than 65% of the sample carried their bags over one or 2 shoulders, 20% used single strap bags carried by one hand and 14.5% had bags with wheels. Over one third of the students reported experiencing bodily pain due to bag carriage.

Conclusion: A considerable proportion of Saudi school boys carried an overloaded and oversized backpacks. Moreover, one third of the sample experienced bodily pain related to school bags. It is recommended that school bags be limited to no more than 5-10% of student's body weight.

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More than 2.5 million elementary school children in Saudi Arabia carry book bags on their shoulders 5 days per week for the entire school year. On a typical day, these dedicated students struggle to maintain posture and balance while carrying overloaded backpacks that contain books and school supplies. Research indicates that backpack loads represent a significant percentage of child's body weight.[1,2] A heavy school bag, especially when it is slung over one shoulder, can lead to muscle strain, distortion of the natural curve of the spine and rounding of the shoulders.[3,4] The heavy school packs carried by the students were previously linked to bodily pain.[2,3,5,6] In fact, backpack weight measured as a percentage of body weight was effective in predicting back pain in adolescents.[7] If such risks persist over many

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schooling years, it can cause chronic back problems that may extend into adulthood.[2,5-7] This has lead several studies to suggest that children should carry no more than 10% of their body weight.[5,6, 8-10] Despite that, a considerable proportion of school children were reported to carry backpacks that were above 10% of their body weight.[1,2] In Saudi Arabia, the extent of this problem has not been yet investigated, though anecdotal evidences for the heavy loads of school bags have been surfacing in the media for some times. Therefore, the purposes of the present study were to investigate the percentage of body weight represented by school bags, to determine the size of school bags relative to trunk size, and to identify the methods of carrying book bags by elementary school boys in Riyadh.

Methods. This is a cross-sectional study conducted on Saudi school boys aged 6-14 years during the Spring of 2005 in Riyadh. It used a multistage random sampling technique. In this study, Riyadh city was divided into 5 geographical areas, and one public school was randomly selected from each area. In addition, one private school was randomly chosen from the major private schools in Riyadh. Only Saudi boys were included in the selection. The number of Saudi boys drawn from each of the public and private schools was proportional to the total number of Saudi boys in each category. Next, one class was chosen at random in each grade. Thus, 6 classes were sampled from each of the chosen schools. All of the Saudi boys in the selected classes were included in the sample. Written consent was obtained from the educational directorate of Riyadh schools as well as from the principals of the selected schools. Body mass was measured without shoes to the nearest 0.1 kg using Seca digital scale (882, Germany). Standing height was measured barefooted to the nearest 0.1 cm using a calibrated measuring rod (Seca Road Rod). Biacromial and bi-iliac widths were measured from the rare to the nearest 0.01 cm with Martin-type anthropometer, according to standard procedures.[11] Moreover, the trunk height was measured from the acromial processes to the ischial tuberosity, while the student sitting on a table with his feet hanging. The total area of the trunk was calculated as both widths of the trunk divided by 2 and then multiplied by trunk height. In addition, triceps and subscapular skinfolds thicknesses were measured on the right side of the body using Harpenden caliper. Body fat percentage was then calculated by a prediction equation specific for children and youth.[12] Obesity was defined as body fat content equals to or exceeds 25% of the total body mass.[13] School bag full with the daily load of books and school supplies was measured to the nearest gram using a special digital scale designed for measuring infant weight (Seca 334, Germany). The height and width of the school bag were also measured using non-stretchable measuring tape. Total area of the school bag was then calculated as its length multiplied by its width. In addition, students were asked, through interviews, to respond to questions related to how they travel to and from school (walk or use car), how they carry the bag, and if they have pain due to bag carriage.

Data entry and statistical analysis were performed using the Statistical Package for the Social Science (SPSS) program, version 10 (Chicago, IL). Data were reported as means and standard deviations or as percentages. Since the clustering unit is the whole class in each grade, comparisons of data were made relative to grade levels from 1-6. Differences between grades or methods of carriage were tested using one-way analysis of variance with Scheffe post test, and the level of significance was set at 0.05 level or less.

Results. A total of 702 school boys were tested spanning from first to sixth grades. **Table 1** shows the anthropometric characteristics of the present sample. All of the physical descriptions significantly increased with advancing age. Body mass increased by almost 100% from the first grade to the sixth. Body fat percent among the whole sample ranged from 6.8-44%. Fat percent on the average increased from 14.2% in boys at grade 1 to 24.6% in boys at grade 6. This represents an overall increase in adiposity of more than 73% over the sixth grades. In addition, the increase in mean subscapular skinfold thickness (152.5%) is much more than that of triceps skinfold thickness (82.1%), indicating a shift toward central obesity with advancing age of boys. The study findings also revealed that the majority (71.2%) of the students travels to and from schools by cars, and only 28.8% walk to and from schools.

Table 2 displays the school bag profile relative to grade levels. School bags averaged 3.23 kg in absolute weight (95% CI = 3.14-3.32 kg). Bag weight of students in the 1st grade was significantly less than the other grades. The maximal weight recorded for school bag was 7.5 kg. Relative to body mass of the students, school bag represented an average weight of 10.7% ± 4.7 (95% CI = 10.3-11.0%). The maximal value for bag weight relative to body mass was 28.7%. Bag weight expressed relative to student's lean body mass decreased from 14.6% in the first graders to 10.1% in the sixth graders. Moreover, 49% of the students were carrying bags weighing more than 10% of their body mass, while about 18% of the students carried bags weighing more than 15% of their body mass. There were slight variations in bags dimensions among school graders. Bag surface area ranged from

Table 1 - Anthropometric characteristics of school boys (n = 702).

Variable	Grade Level						P value *
	1 (n = 110)	2 (n = 118)	3 (n = 114)	4 (n = 105)	5 (n = 120)	6 (n = 135)	
Age (years)	7.2 ± 0.62	8.2 ± 0.66	9.3 ± 0.76	10.4 ± 0.78	11.3 ± 0.58	12.5 ± 0.74	0.000
Body mass (kg)	22.6 ± 3.8	26.2 ± 5.9	29.7 ± 7.0	34.7 ± 10.0	38.2 ± 10.6	44.1 ± 13.6	0.000
Body height (cm)	119.9 ± 5.7	125.1 ± 5.9	131.2 ± 5.4	135.4 ± 6.7	140.6 ± 6.5	146.7 ± 7.5	0.000
Body mass index	15.7 ± 1.9	16.6 ± 2.7	17.1 ± 3.3	18.7 ± 4.3	19.1 ± 4.3	20.2 ± 4.9	0.000
Body surface area (m^2)	0.87 ± 0.08	0.95 ± 0.11	1.04 ± 0.12	1.13 ± 0.16	1.21 ± 0.17	1.33 ± 0.20	0.000
Biacromial width (cm)	27.2 ± 2.0	28.4 ± 1.9	29.4 ± 2.0	30.9 ± 2.2	31.7 ± 2.3	33.4 ± 2.8	0.000
Bi-iliac width (cm)	18.8 ± 1.3	19.9 ± 1.8	20.4 ± 1.9	21.4 ± 2.1	22.4 ± 2.6	23.4 ± 3.3	0.000
Trunk height (cm)	35.1 ± 4.8	36.8 ± 5.4	40.6 ± 3.5	42.2 ± 3.9	44.2 ± 3.6	46.0 ± 4.7	0.000
Trunk area (m^2)	0.81 ± 0.14	0.89 ± 0.16	1.01 ± 0.13	1.11 ± 0.17	1.20 ± 0.17	1.31 ± 0.24	0.000
Triceps skinfolds (mm)	8.9 ± 3.3	10.7 ± 4.7	10.9 ± 5.2	13.8 ± 8.0	14.4 ± 8.2	16.3 ± 9.5	0.000
Subscapular skinfolds (mm)	5.9 ± 3.2	7.4 ± 5.1	8.5 ± 7.2	11.8 ± 10.4	13.5 ± 11.4	14.9 ± 12.5	0.000
Fat percent (%)	14.2 ± 5.2	16.9 ± 7.2	17.7 ± 8.3	21.5 ± 10.9	22.9 ± 11.5	24.6 ± 11.2	0.000
Lean body mass (kg)	19.3 ± 2.4	21.4 ± 3.3	23.9 ± 3.4	26.3 ± 4.1	28.3 ± 4.1	32.1 ± 6.0	0.000

Data are means ± standard deviations. *Differences between grade levels.

Table 2 - Descriptive characteristics of school bag (values are mean and standard deviation).

Variable	Grade Level						*P* value*
	1 (n = 110)	2 (n = 118)	3 (n = 114)	4 (n = 105)	5 (n = 120)	6 (n = 135)	
Bag weight (kg)	2.77 ± 0.99	3.40 ± 1.12	3.28 ± 1.09	3.50 ± 1.29	3.31 ± 1.24	3.14 ± 1.29	0.000
Bag weight relative to body mass (%)	12.5 ± 4.9	13.4 ± 4.6	11.5 ± 4.3	10.7 ± 4.5	9.1 ± 3.6	7.7 ± 3.7	0.000
Bag weight relative to lean body mass (%)	14.6 ± 5.5	16.1 ± 4.5	13.9 ± 4.8	13.5 ± 5.1	11.7 ± 4.1	10.1 ± 4.5	0.000
Bag height (cm)	37.0 ± 3.6	37.8 ± 3.8	38.7 ± 3.8	37.3 ± 4.3	37.3 ± 4.9	36.7 ± 5.4	0.011
Bag width (cm)	27.1 ± 2.6	27.9 ± 2.7	28.3 ± 2.8	27.6 ± 2.6	27.9 ± 3.7	27.6 ± 4.1	0.101
Bag surface area (m^2)	1.01 ± 0.16	1.06 ± 0.17	1.10 ± 0.19	1.04 ± 0.19	1.06 ± 0.25	1.03 ± 0.28	0.029
Bag area /student's trunk area (%)	128.5 ± 32.7	122.6 ± 29.9	109.8 ± 21.7	96.0 ± 23.7	89.5 ± 24.8	80.8 ± 24.8	0.000

*Differences between grade levels.

1.01 m^2 in the 1st grade to 1.10 m^2 in the third grade. The ratio of bag surface area to student's trunk area decreased from 129% in the first grade to 81% in the sixth grade. The maximal ratio of bag surface area to student's trunk area was 237%.

The school bag carriage profile is shown in **Table 3**. The majority of students carried their book bags on one (32.3%) or 2 (33.0%) shoulders. Approximately 20% of the school boys used single strap bags that were carried by hand and 14.5% of the students had bags with wheels. Furthermore, wheeled backpacks were significantly heavier (4.4 ± 1.1 kg) and larger (1.15 ± 0.18 m^2) than non-wheeled backpacks. They also represented a higher percentage of student body mass (15.7 ± 5.3%) compared to the other types of backpacks. Bags carried by hand were lighter (2.5 ± 0.9 kg) and smaller (0.86 ± 0.23 m^2) than the other types of bags. They were also carried by older students. In addition, the proportion of students who experienced bodily pain due to backpack carriage was 35.6%. Shoulder pain represented the highest bodily pain reported by the students (33.2%). Shoulder pain was also more frequently experienced by those students carrying their bags on one shoulder, and by older students compared with younger boys (p=0.014). The weight of school bag was not significantly different between students reporting pain and those not reporting pain (3.3 ± 1.2 kg versus 3.2 ± 1.2 kg; p=0.38).

Discussion. The present study reports for the first time on school backpack profile of elementary students in Saudi Arabia. Despite the relevance of this issue to students' health and well-being, no local data has been previously published on this matter. Elsewhere, however, there are numerous published studies addressing the physical, biomechanical and physiological demands of school bag carriage.[1-10, 14-17] The present investigation revealed some interesting

Table 3 - School bags description relative to methods of carriage.

Variable	Carrying method				Difference between methods*
	On 2 shoulders (1)	On one shoulder (2)	By hand (3)	On wheels (4)	
Proportion of students (%)	33	32.3	20.2	14.5	
Age (years)	9.1 ± 1.6	10.3 ± 1.8	11.2 ± 1.9	9.1 ± 1.8	1 ≠ 2 and 3 2 ≠ 3 and 4 3 ≠ 4
Bag weight (kg)	3.3 ± 1.7	3.2 ± 1.0	2.5 ± 0.9	4.4 ± 1.1	1≠3 and 4 2≠3 and 4 3≠4
Bag weight relative to body mass (%)	11.7 ± 4.0	9.7 ± 3.6	7.2 ± 3.0	15.7 ± 5.3	1 ≠ 2, 3 and 4 2 ≠ 3 and 4 3 ≠ 4
Bag surface area (m^2)	1.11 ± 0.18	1.06 ± 0.19	0.86 ± 0.23	1.15 ± 0.18	1 ≠ 2 and 4 2 ≠ 3 and 4 3 ≠ 4

* One-way analysis of variance results with p value <0.05; ≠ Not equal.

findings. Saudi school boys carry substantial loads on their shoulders averaging nearly 11% of their body mass. Moreover, school bags, relative to the student trunk area, were shown to be oversized, especially for the younger students. Similar findings were reported from South African students with a mean age of 12.2 years.[2] In a study involving elementary students from the United States, it was found that 26% of them carried backpacks that weighed at least 10% of their body mass.[1] Our findings that school backpacks relative to body mass decreased with advancing age of students is contrary to a recent report that found school backpacks relative to body mass significantly increased from 6.2% among kindergartners to 12.05 among fifth graders.[1] The American Chiropractic Association (ACA) recommends limiting the backpack's weight to no more than 10% of the child's body mass. It also urges the use of ergonomically correct backpack.[18] Walking with a backpack of greater than 10% of body mass was shown to induce significant changes in trunk posture and respiratory parameters in 10-year-old children.[15] Indeed, Lai and Jones demonstrated that when school-bag load exceeded 10% of body mass, a restrictive effect on child's lung volume occurred.[10] Moreover, carrying backpack prompted a significant decrease in stride length and an increase in stride frequency compared with no bag.[4] It was also shown that in adolescents 12-18 years, backpacks positioned at T7 produced the largest forward (horizontal) displacement compared to T12 and L3.[17] In addition, the heavier the backpack, the more pressure is placed on the spine column and back muscles. Excessive load on the back forces the child to bends forward in order to support the weight on the back rather than on his shoulders.[3] Furthermore, incorrectly fitted or wrongly packed school bag can add to the strain already placed on the child's back and shoulders by the heavy backpack. In a simulated school students load carriage, it was demonstrated that backpack weight had the greatest influence on shoulder strap tension and shoulder pressure.[3] The present investigation showed that over one third of the students were experiencing bodily pain due to carrying school backpack. Our findings agree with those reported in the literature. Lyer indicated that about half of the students in his study experienced pain, mostly shoulders and back pain.[6] He also found that the less heavy the backpack carried by the student the less frequently pain was reported. In a study, conducted on 6-year old children from Italy, school backpacks caused back pain in 46.1% of the students.[16] In addition, a study involving school children aged 11-14 years from South Africa reported that most of the children experienced shoulders and a combination of shoulders and other bodily pain.[2] In a large sample of adolescents from the United States, a nonspecific mechanical pain was found prevalent among the students, and that the severity of pain was influenced by method of wear, older age, and walking to and from the school.[7] In the present study, bag weight did not have a significant influence on bodily pain. However, pain was felt more frequent by older boys and those who carried bags on one shoulder. This is in contrast to findings from Puckree et al who

reported more pain in children carrying bags on 2 shoulders.[2] Other researchers found that time spent carrying the backpack is associated with back pain the most.[16] While the weight load may be influencing factor, some of the problems and pain associated with book bag carriage can be attributed to how the packs are carried. Students should distribute the majority of the weight on the hips and tightening the hip strap. Backpacks must also be kept close to the back. Our findings indicated that 33% of the students carried their backpacks on 2 shoulders. This figure is not far from the 39.2% reported from South African children.[2] Moreover, approximately 15% of boys in our study used wheeled bags. However, this percentage is much higher than what was reported in a recent study indicating only 3.5% of their students had backpacks with wheels.[1] The same study also indicated that wheeled backpack users were significantly older and more likely to be girls.[1] In our study, wheeled backpack users, however, were younger boys and had heavier book bags and larger bag surface area to trunk ratio than older boys. Having heavy and oversized backpacks may create additional strain on the child's back and shoulders. Finally, the present report demonstrated that the majority of school boys travel to and from the school by car. Elementary schools in Riyadh as well as in the rest of the country are usually located in nearby communities and should be in close proximity to the students' homes. Despite that, the majority of the students in this sample did not walk to and from the school. With such high prevalence of obesity among Saudi school children, as shown in the current report as well as in previous studies,[19, 20] walking to and from the school can boost the child's energy expenditure and contribute to energy balance. Walking will also increase the levels of daily physical activity for the children. However, walking to and from the school while carrying heavy backpack could place an enormous strain on the spinal column and back muscles of the child.

In summary, Saudi school boys seem to carry substantial backpack load. Backpack loads represented a significant percentage of children's body mass. Almost 50% of the students in this study carried book bags weighing more than 10% of their body mass. The majority of the boys carry their bags on 1-2 shoulders. Furthermore, over one third of the sample experienced bodily pain, mostly shoulders pain, due to school bag carriage. Therefore, it is recommended that backpack weight be limited to no more than 5-10% of the child's body mass. Students should avoid carrying their bags over one shoulder and have the backpack properly packed and fitted. Lastly, since the present study included boys only, it seems that there is a need to examine the issue of backpack loads in school girls as well.

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