Assessment of weight and mode of transport of school material in highschool students

Avaliação do peso e do modo de transporte do material escolar em alunos do ensino fundamental

Evaluación del peso y del modo de transporte del material escolar en escolares de la enseñanza fundamental

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ABSTRACT

Objectives: To identify the way school material is carried and the weight of the material carried, and to compare these findings for 2nd, 5th and 9th graders.

Methods: This study evaluated 58 students from a randomly selected school in Dois Irmãos, a city in southern Brazil, using anthropometric variables and a questionnaire to identify what schoolchildren used to carry school material and the way it was carried. School material was weighed over a five-day period. Descriptive statistics was used to analyze the responses to the questionnaires. Mean weight of the school material, normalized by body weight, was analyzed using one-way ANOVA and the Bonferroni post hoc test (α=0.05).

Results: Second, 5th and 9th graders carried their own material using a backpack with two straps (60.0%, 77.3%, and 85.5%, p<0.05) over their shoulders (60.0%, 77.3%, and 81.0%, p<0.05), and mean rate of schoolbag weight to body weight was 7.2%±2.3, 8.8%±3.0, and 5.9%±1.7. The only significant difference (p<0.05) was between 5th and 9th graders.

Conclusion: Students in the 2nd, 5th and 9th grades prefer to carry their school material using a backpack with two straps symmetrically placed over the shoulders. Regardless of school grade, the backpack weight was less than 10% of body weight, and 5th graders carried the heaviest relative loads.

Key-words: posture; teaching; health promoting; weight-bearing.

RESUMO

Objetivos: Identificar e comparar o modo de transporte e o peso do material escolar utilizado por escolares entre o 2º, 5º e 9º anos do ensino fundamental.

Métodos: Dentre as escolas do município Dois Irmãos (RS), uma escola foi sorteada e 58 escolares foram pesquisados por meio de questionário, que avaliou o acessório utilizado para transportar o material escolar e a forma de transporte. As variáveis antropométricas e o peso do material escolar foram mensurados ao longo de cinco dias. A análise do questionário envolveu tabelas de frequência e teste do qui-quadrado. O peso médio do material, relativo ao peso corporal e registrado ao longo da semana, foi analisado por ANOVA *one-way* e ao teste *post hoc* de Bonferroni.

Resultados: Escolares do 2º, 5º e 9º anos transportam seu material nas costas, em mochila com duas alças (60, 77,3 e 85,5%, respectivamente, p<0,05), apoiadas sobre os ombros (60, 77,3 e 81%, respectivamente; p<0,05). A média do peso da mochila relativo ao peso corporal no 2º, 5º e 9º anos foi 7,2±2,3, 8,8±3,0 e 5,9±1,7%, respectivamente, com diferença significativa apenas entre escolares do 5º e 9º anos.

Conclusões: Os escolares do 2º, 5º e 9º anos transportam preferencialmente seu material escolar utilizando a mochila com

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duas alças nas costas apoiadas simetricamente sobre os ombros. Independentemente do ano escolar, o peso da mochila transportada foi inferior a 10% do peso corporal; os escolares do 5º ano foram os que transportaram mochilas com maiores cargas.

Palavras-chave: postura; ensino; promoção da saúde; suporte de carga.

RESUMEN

Objetivos: Identificar y comparar el modo de transporte y el peso del material escolar utilizado por escolares entre el 2º, 5º y 9º años de la enseñanza fundamental.

Métodos: Entre las escuelas del municipio de Dois Irmãos (RS, Brasil), una escuela fue sorteada y 58 escolares fueron investigados mediante cuestionario, que evaluó el accesorio utilizado para transportar el material escolar y la forma de transporte, las variables antropométricas y el peso del material escolar fueron medidos a lo largo de cinco días. El análisis del cuestionario envolvió tablas de frecuencia y test del chi-cuadrado. El peso mediano del material, relativo al peso corporal, registrado a lo largo de la semana, fue sometido por ANOVA *one-way* y por el test *post hoc* de Bonferroni (α=0,05).

Resultados: Escolares del 2º, 5º y 9º años transportaron su material a la espalda, en mochila con dos asas (60, 77,3 y 85,5%, respectivamente, p<0,05), apoyadas sobre los hombros (60, 77,3 y 81%, respectivamente; p<0,05). El promedio del peso de la mochila relativo al peso corporal en el 2º, 5º y 9º años fue 7,2±2,3, 8,8±3,0 y 5,9±1,7%, respectivamente, con diferencia significativa solamente entre los escolares del 5º y 9º años.

Conclusiones: Los escolares del 2º, 5º y 9º años transportan preferencialmente su material escolar utilizando la mochila con dos asas a la espalda apoyada simétricamente sobre los hombros. Independientemente del año escolar, el peso de la mochila transportada fue inferior al 10% del peso corporal; los escolares del 5º años fueron los que transportaron mochilas con mayores cargas.

Palabras clave: postura; enseñanza; promoción de la salud; soporte de carga.

Introduction

Pain and posture problems, common in the adult population[1-4], are also found, in large proportions, in childhood and adolescence[5-8]. Paananen *et al*[9] demonstrated that the occurrence of musculoskeletal pain in two or more anatomic sites is frequent among young schoolchildren. Detsch *et al*[10] found a prevalence of 66% for lateral posture changes and 70% for anteroposterior changes of the spine in childhood and adolescence.

Siivola *et al*[11] reported that back pain and posture problems in young people may have multifactorial causes. For example, the use of heavy backpacks and carrying them transportation asymmetrically, long periods of time in an inadequate posture while sitting[11], the use of inappropriate furniture, watching television for a long time[12] are risk factors for the development of back pain and posture problems[13,14] among young people.

Both body posture when carrying school material and the size of the load carried are risk factors associated with back pain and posture problems[15-18]. Carrying school material seems to have an important effect on the health and well-being of schoolchildren because of the amount and distribution of efforts over musculoskeletal structures, which may intensify or mitigate negative effects and the role of overloads to the spine[3,19].

Posture changes and back pain are associated with the lack of adequate posture habits during activities of daily living (ADL)[1,20,21], and these variables should be thoroughly investigated in childhood and adolescence. This study (1) identified the way children carried school material and measured the weight of the school material carried; and (2) compared findings between 2nd, 5th and 9th graders.

Method

This cross-sectional study was conducted in the city of Dois Irmãos, Brazil, from June to July 2012. Data were collected prospectively. Sample size was calculated according to the mean population estimate according to Santos, Abbud and Abreu[22]. A 95% confidence interval, a 10% maximum estimate error over mean (11.7%) relative weight of schoolbag over body weight of schoolchildren[19], and a standard deviation (±4.3%) according to the literature[19] were used to calculate the minimum number of schoolchildren for the purposes of this study, and the result was 52.

Elementary school goes from the 1st to the 9th grade in Brazil, in a total of 9 school years divided into three phases in this study: (1) initial years, from the 1st to the 3rd grade; (2) intermediate years, from the 4th to the 6th grade; (3) final years, from the 7th to the 9th grade.

In the first phase of sample collection, after the definition of the classification of school grades, a simple draft[23] was

conducted to choose which school would participate in the study from all the 9-grade elementary schools in the city of Dois Irmãos, a city in the State of Rio Grande do Sul, Brazil.

In the second phase of the sampling procedures, after the school was chosen, another draft defined, only in that school, which groups would be included in the study[23]. In that phase, the classification of school grades was used; that is, for each of the phases (initial grades, intermediate grades and final grades), a simple draft included all the groups in the school that were included in each phase. Three groups were chosen, a 2nd, a 5th and a 9th grade of elementary school (ES), representing the initial, intermediate and final grades of ES.

Inclusion criteria were: to be regularly enrolled in the ES under evaluation, to be seven to 18 years old, not to have any lesion or any other reason not to carry a schoolbag. Schoolchildren were excluded if they were absent in any of the five days of the week when the measurements were made.

The study included 58 schoolchildren aged seven to 16 years and attending the 2nd (n=15), 5th (n=22) or 9th (n=21) grades of ES in that school. All schoolchildren participated voluntarily, and their participation was authorized by their parents or guardians, who signed an informed consent term. In a similar way, an authorization to conduct the study in its premises was obtained from the school board. The study was approved by the Ethics in Research Committee of Universidade Federal do Rio Grande do Sul (UFRGS) under no.19832, in agreement with Resolution 196/96 of the Brazilian National Health Council.

Three data collection procedures were used: questionnaire: (2) measurement of anthropometric variables; (3) measurement of school material weight.

The questionnaire (available from the corresponding author) had four multiple choice questions, the first two with illustrations in the form of photographs to facilitate interpretation by the schoolchildren. This instrument evaluated how the schoolchildren usually carried their school material, and was prepared especially for this study based on previous observations of the types of backpacks, schoolbags and briefcases used by the students in that school to carry their school material.

To determine the specificity of the questionnaire, that is, the quality of data generated by the questionnaire, standard procedures described in the literature were followed[23,24]. According to Thomas and Nelson[24], the basic criteria to judge the quality of measurements used in the collection of research data are validity and reliability (p. 196). Measurement validity, defined by the validity of questionnaire content, indicated the degree to which the tool measures what it is expected to measure, that is, validity refers to the safety of interpretation of the instrument. Therefore, in this study, questionnaire content validity was determined by the analysis of three specialists in posture education. The results of that analysis revealed that the instrument was applicable and specific to accurately assess what it was expected to evaluate. Still according to Thomas and Nelson[24], "reliability is an important part of validity, which refers to the consistency or possibility of reproducing a measurement" (p.201). To confirm questionnaire reliability, it underwent test and retest at a 15-day interval with a group of 15 schoolchildren not participating in the study[23,24]. The test-retest results underwent statistical analysis (Spearman correlation and Wilcoxon test), which showed that all the correlations were strong ($r \geq 0.94$) and significant ($p \leq 0.01$) and that there were no significant differences ($p \geq 0.9$) between test and retest responses. The results of content validation and reliability procedures showed that the questionnaire had clear and objective questions adapted to the age group under study and high reliability indices[23,24].

Height was measured using a measuring tape reading to 1mm, fixed on the wall. Schoolchildren were barefoot and standing with their back against the wall and their gaze should be fixed horizontally. Measurements were made from the top of the head to the plantar area. For readings, a rod was used to ensure horizontal positioning during measurements and to avoid errors resulting from inclination. Height was recorded in centimeters.

The body mass of schoolchildren was measured using a digital scale (Britânia – São José dos Pinhais/Brazil) reading to the nearest 100g. For that evaluation, schoolchildren were asked to be barefoot and to wear light clothing, such as shorts and tank tops for girls and trunks for boys.

To define the mass of school material, the backpacks, schoolbags or briefcases were evaluated during a whole week, from Monday to Friday. On those five days, the mass of the school material of all children was measured five times to ensure that the mean value represented the reality of schoolchildren and to assess the variation of loads along the week.

Height and body mass were used to calculate body mass indices (BMI). Body weight (bw) of the schoolchildren was calculated multiplying body mass by gravity acceleration, and the result was recorded in newtons. The weight of the material (mw) was calculated by multiplying the mass of the material by gravity acceleration, and the result was

also recorded in newtons. To analyze the weight of school material, the simple arithmetic mean value of the weights recorded along the measurement week was calculated, A proportion index (PI, as a percentage) was also calculated as the rate of body weight to backpack weight using the following equation: PI=mw x 100/bw, in which *mw* was the weekly mean value of the school material weight in newtons, and *bw*, the body weight of the schoolchild in newtons. The greater the PI, the greater the relative weight of the backpack to the schoolchild's body weight.

The SPSS 17.0 was used for statistical analysis. Data normality (Shapiro-Wilk test) and homogeneity of variance (Levene test) were confirmed. One-way ANOVA and the Bonferroni post hoc test were used to check whether there were significant differences in *mw* between the days of the week and in PI between school grades. Nominal variables (type of schoolbag, way it was carried, unnecessary material carried, and effort demands) were analyzed according to frequency tables. In addition, a chi-square test was used to check whether there were significant differences (1) between frequencies of response for each group (intragroup analysis) and (2) between frequency of responses for the 2nd, 5th and 9th grades (intergroup analysis). The level of significance was set at 0.05.

Results

Table 1 shows the results of age, body weight, height and BMI in each school grade (2nd, 5th and 9th grades).

Table 2 shows mean weight of school material for the week and for each day separately. The results of one-way ANOVA revealed significant differences in school material weight between the days of the week in each school grade. Particularly, in the second grade, there was a difference between Thursday and Friday. In the 5th grade, the differences were between Monday and Wednesday and between Wednesday and Thursday. In the 9th grade, the difference was between Monday and Friday.

Mean PI values for the 2nd, 5th and 9th grades were 7.2%±2.3. 8.8%±3.0 and 5.9%±1.7. These results showed that schoolchildren carried school material (backpacks) that had a mean weight of less than 10% of their body weight, and that 5th graders carried the greatest relative load. Of all the schoolchildren in each group under analysis, 26.7%, 31.8% and 0% had PI greater than 10% in the 2nd, 5th and 9th grades. The results of one-way ANOVA revealed that PI was significantly different only between the 5th and the 9th graders (p=0.001).

The analysis of questionnaire responses about the schoolbag used to carry school material and the way the bag was carried revealed that, regardless of school grade, a two-strap backpack was the schoolbag most often used by most schoolchildren, that is, for 60%, 77.3% and 85.7% of 2nd, 5th and 9th graders. Most students carried their backpacks on their back and placed the straps over their shoulders (50%, 77.3% and 81% of 2nd, 5th and 9th graders). The comparison of the questionnaire responses about the type of schoolbag and the way that it was carried revealed no significant differences between the three school grades.

Table 4 described the frequency of questionnaire responses about unnecessary material carried to school, that is, that had not been asked on that school day, and the evaluation of effort according to the amount of material demanded every day for classes. The analysis of the questionnaire responses about unnecessary material carried to school revealed that 5th graders were the ones that carried the least unnecessary material (p=0.01) when compared with 2nd and 9th graders. The evaluation of effort demanded

Table 2 - Mean and standard deviation of school material weight in 2nd, 5th and 9th school grades on each day of the week and mean value for the five days of the week

Days	2nd grade	5th grade	9th grade
Monday	22±7	31±12[b]	30±10[d]
Tuesday	19±6	33±12	34±12
Wednesday	17±6	41±12[b,c]	36±12
Thursday	24±8[a]	31±12[c]	36±10
Friday	16±7[a]	32±8	41±10[d]
Mean	19.8±6	33.3±10	35.3±9

Significant difference in school material weight between two days of the week: [a]p=0.038; [b]p=0.036; [c]p=0.033; [d]p=0.013

Table 1 - Mean and standard deviation of age, body weight, height and body mass index of schoolchildren in the 2nd, 5th and 9th grades

Grades	Age (years)	Body weight (N)	Height (cm)	BMI (kg/m²)
2nd grade (n=15)	7.9±0.4	275±56	130.3±0.7	16.27±1.9
5th grade (n=22)	10.4±0.8	393±85	146.1±0.8	18.43±2.7
9th grade (n=21)	14.5±1.1	614±122	169.4±0.8	21.49±3.5

N: Newton

Table 3 - Frequency of type of schoolbag to carry school material and way it was carried by 2nd, 5th and 9th graders: comparison (chi-square test) between frequency of responses for each grade (intragrade analysis)

Schoolbag	2nd grade		5th grade		9th grade	
	Frequency	%	Frequency	%	Frequency	%
Backpack with wheels	2	13.3	0	0	0	0
Briefcase with handle	1	6.7	2	9.1	0	0
Backpack with two straps	9[a]	60	17[b]	77.3	18[b]	85.7
Bag	2	13.3	1	4.5	0	0
One-strap backpack	1	6.7	2	9.1	3	14.3
Total	15	100	22	100	21	100
Way to carry it						
Two-strap backpack on the back	9[c]	50.0	17[c]	77.3	17[c]	81
Wheels on the ground	1	6.7	0	0	0	0
One-strap backpack on the back	1	6.7	2	9.1	3	14.3
Bag on one side of the body	1	6.7	0	0	0	0
Briefcase in the hand	1	6.7	2	9.1	0	0
Bag with strap across the chest	1	6.7	1	4.5	0	0
Two-strap backpack on the back, using one strap over the shoulder	1	6.7	0	0	1	4.8
Total	15	100	22	100	21	100

Greater frequency than for the other types of schoolbag: [a]p=0.005; [b]p=0.001. Greater frequency than for the other ways of carrying the material: [c]p=0.001

Table 4 - Frequency of unnecessary material carried to school and evaluation of the effort demanded in relation to the amount of material requested daily for classes; comparison (chi-square test) between response frequencies for each grade (intragrade analysis).

Carrying unnecessary material	2nd grade		5th grade		9th grade	
	Frequency	%	Frequency	%	Frequency	%
Yes	8	53.3	5	22.7	13	61.9
No	7	46.7	17[a]	77.3	8	38.1
Total	15	100	22	100	21	100
Effort demanded						
Very little	0	0	1	4.5	1	4.8
Little	3	20.0	3	13.6	0	0
Reasonable	9[b]	60.0	12[c]	54.5	12[d]	57.1
Very much	2	13.3	6	27.3	5	23.8
Too much	1	6.7	0	0	3	14.3
Total	15	100	22	100	21	100

[a]Greater frequency of carrying unnecessary material (p=0.017). Greater frequency than the other levels of demand: [b]p=0.017; [c]p=0.005; [d]p=0.004

for the amount of material required for classes everyday (Table 4) revealed that the level of demand most often reported by schoolchildren was "reasonable" (60%, 54.5% and 57.1%, for the 2nd, 5th and 9th grades). The comparison of questionnaire responses about the effort demanded in relation to the amount of material required for classes every day showed that there were no significant differences between the three grades.

Discussion

This study identified the weight of school material and the way that it is carried and compared findings between 2nd, 5th and 9th graders in the city of Dois Irmãos, Brazil. The main results revealed that, regardless of school grade, the most frequent way to carry school material was a two strap backpack carried on the back (75.9% of all schoolchildren)

and with the straps placed over the shoulders. Similar results were reported by Aparicio *et al*[25], who evaluated the way the backpack was carried by 203 schoolchildren in Salamanca, Spain, and found that practically all students under evaluation used two-strap backpacks.

Other studies found the same preference to carry the backpack with the two straps over the shoulders, but at much lower percentages[10,17,20], which raises concerns because inadequate postures to carry school material are significantly associated with low back pain and musculoskeletal symptoms in schoolchildren.

In addition, according to Whittfield, Legg and Hedderly[19], the most adequate way to carry school material is to place the backpack at the level of the dorsum and put the straps over the shoulders, tightly fit and with no gaps. Loosely fit straps may result in overloads to the dorsal region and lead to kyphosis and, as compensation, to lumbar and cervical lordosis. Our findings are corroborated by Gent *et al*[17], Korovessis *et al*[20] and Brackley e Stevenson[26], who demonstrated that the backpack should be carried symmetrically over both shoulders so that the load is distributed uniformly. Otherwise, inclination torques, harmful to the spine, may lead to low back pain and musculoskeletal symptoms along the years.

According to Brackley and Stevenson[26], the ideal maximal backpack load, based on physiological parameters, should be 10% to 20% of the schoolchild's body weight, whereas more cautious findings by other authors suggest that the load carried should not exceed 10% of the schoolchild's body weight[19,27,28]. In this sense, mean values for each school grade in our study were within the acceptable standards defined in the literature. In addition, data about weight of material carried revealed that 9th graders carry the greatest amount of weight to school. However, the analysis of the PI relative to body weight revealed that 5th graders are those that carry the greatest relative weight. Of all the schoolchildren, 20% had PI greater than 10%. However, in all groups no child had a PI greater than 15%.

Similar studies[17,19,29] evaluated schoolchildren and found that backpack weight increases significantly with age, ranging from 5% to 29% of the body weight and exceeding the recommended limit of 10%.

In countries such as Spain, Greece, Holland and New Zealand there seems to be a greater concern about the evaluation of weight excesses, the time spent carrying the school material and the way schoolchildren carry it, and several publications have discussed it. Results from other countries may not fit the Brazilian reality, and we understand that it is not ideal to extrapolate them to the Brazilian population or to use them as basis for the creation of our public and educational policies. Moreover, very few studies in the literature evaluated the way school material is carried by schoolchildren in different regions of Brazil, and the data in this study, as a first step, are important both for the development of this type of study in different regions of Brazil, with larger samples and investigating more issues, such as the time that this material is carried, and for the development and proposal of public education and public health policies.

An interesting option to mitigate the problems associated with poor posture in ADL, such as inappropriate ways to carry school material[11,30], excess weight[11,30], and time spent carrying school material[31], is the development of a Posture Education Program (PEP) in the school environment, whose purpose should be to teach the correct postures for ADL and to avoid, therefore, damage to the spine due to inadequate postures[32,33]. In this sense, studies in the literature show that PEP participants in different age groups tend to make positive changes in their posture during ADL[32-36]. However, data about the reality of schoolchildren are necessary to develop this type of program so that its contents respond to actual needs[32-34].

Further studies should be conducted to understand the diverse aspects of posture among schoolchildren. The results reported here may be useful to guide Physical Education planning, as well as planning of activities for the whole school. However, although these results are important to raise awareness among educators, they may not be extrapolated to all regions in Brazil because of the many genetic, social and cultural differences between the different states in Brazil, which may be the main limitation of this study, which found that schoolchildren in the 2nd, 5th and 9th grades carried backpacks preferably on their back and with two symmetrically positioned straps over the shoulders, and backpacks weighed less than 10% of their body weight.

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