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Backpacks and school children's obesity: challenges for public health and ergonomics

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Abstract. This descriptive study of cross sectional has focused on analyzing the school material weight transported by students associated with children and adolescents overweight in primary and secondary schools. Participants 339 students of both genders, aged 10-19 years. 243 students carrying and average load of 12.65% of his body weight. 53 students were overweight with a BMI of 20,00 to 35,6. 20 overweight students carrying backpacks more than 10% of his body weight. 21% of the students rated complained of back and shoulder pain. This data is very important in the preventive aspects for the individuals studied, as well as others with the same anthropometric characteristics and the same demand.

Keywords: school backpack, ergonomics, BMI, back pain, posture.

1. Introduction

The ergonomic scientific community, recently, has been alerted to the problem of load carried by young people in school backpacks. The discussions are based in studies conducted by ergonomics, anthropometry and biomechanics, and are related to the complexity of the tasks in the classroom and students interaction with the transportation of school supplies.

These students, in almost all, meet the daily routine of material transport during educational period, comprising phases of primary and secondary schools, and this routine, the backpack is the most used facility to load the material.

Conversely, the same backpack that was apparently designed to bring ease and comfort on the way home from school, children and adolescents may refer to serious and incalculable postural deviations. Thus, individuals who use backpacks with design setting dorsal or scapular may present a set of postural changes that trigger significant damage to structures due to musculoskeletal and postural adjustments to compensating actions that arise with the application of asymmetric loads [11].

The postural deviations have been considered as a serious public health problem in view of its great impact on the population, bringing as a consequence, permanent or temporary disability [2, 4, 11].

Recent studies have identified also that the load carried in school bags, can be a risk factor for the onset of back pain in children and adolescents, and that symptoms may persist into adulthood [8, 9, 13, 22].

It is important to note that, from birth to 20 years, mostly between seven and fourteen years, is that the bone deformities develop, and in this age group is a right moment to implement postural corrections, since the bone structure becomes more rigid as the chronological age increases [8, 9]. So, since

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transportation of the didactic material is a daily routine which is repeated over consecutive years, a special care is needed to avoid postural deviations that may occur in the medium and long term. The way the load is carried is individual and can be determined by factors such as size, volume and shape of the load, weight, transportation time, weather, terrain, physical characteristics and constitution of the individual. The postural imbalances generated in these situations are compounded by the fact that the weight carried is often disproportionate to body mass and the inappropriate use of the backpack and it can be aggravated by overweight and obesity [6, 22].

Obesity can be defined as the degree of fat storage in the body associated with health risk due to its relationship with several metabolic complications. The use of anthropometric indicators is considered one of the best parameters for evaluating and monitoring the health of children and adolescents [1].

The body mass index (BMI) is the most recommended index for the measure of obesity at the population level and at the clinical practice. It is estimated by relationship between body mass and height, and expressed in kg/m2 [1].

In developed countries obesity is considered a public health problem and the World Health Organization (WHO) is considering it as a global epidemic. In the United States the prevalence of obesity accounted for approximately 15% among children and adolescents during the period from 1999 to 2002. What is occurring is a trend of overweight increasing in the population group most numerous, which has prompted the recognition of obesity question as relevant to the collective and individual health [1].

The weight of school bag exceeding 10% of body mass associated with BMI becomes an interesting research topic since the ergonomic demand is high and there are few published references regarding this matter.

2. Objective

This study aimed to quantify the percentage of the weight of school materials transported, associated to the aggravation with overweight children and adolescents in primary and secondary schools in the city of Vespasiano/MG.

3. Materials and methods

This study was approved by the Ethics Committee of the University of the Sacred Heart, Bauru (SP) and characterized as a descriptive and cross-sectional study. 339 students participated, 196 were female (57.8%) and 143 males (42.2%) aged 10 to 19 years (mean 14.01 ± 2.12 SD) with 229 students 110 elementary and high school. A class of each grade participated in the study, and they were selected through a random drawing. The individuals responsible for sample signed a consent form, which explains the objectives and the research steps. The parental consent was an inclusion criterion.

The material and equipment used were a digital scale, brand Plenna Slim model MEA - 02510, capable of 0 -150 kg and 100 g precision; Sanny stadiometer with a capacity of 2.10 m to the nearest 0.1 cm. Protocols for the recording of socio-demographic data - age, gender, weight individuals, the weight of school supplies, class, height, and models used for the transport of materials. We investigated also the incidence of localized pains in the back and shoulders, time of onset of symptoms and mode of transport to make the journey from home to school and vice versa, being considered on foot or vehicle use (bus or car).

An evaluation of the participants where the measures of body mass and weight of the material was obtained in a single collection. Both the students and school materials were weighed on the same scale. To collect more accurate data about the student's body mass and weight of the material was chosen location with a regular floor for proper placement of the scale (calibrated properly). It was established as a criterion, that students should be heavy to be wearing a gym uniform (shorts and shirt), standing erect in the center of balance, with the arms parallel to the body, barefoot, eyes fixed on the horizon, without move and without accessories (watch, wallet, cell phone) that could alter the total body mass. To check the height a Sanny stadiometer was used.

The students were evaluated in the standing position, with bare feet and parallel. The ankles, shoulders and buttocks touching the wall. Measurements of weight and height were used to calculate Body Mass Index (BMI). The weight in kilograms was divided by the square of height in meters. For the diagnosis of normal weight individuals, overweight and underweight was used as a parameter the distribution of BMI by age and gender of the reference National Health and Nutrition

Examination Survey (NHANES). From the value obtained should compare it with the reference from the tables of BMI percentile for age and gender. For the diagnosis of overweight cutoff point is established for adolescents ≥ 85 percentile, corresponding to the classification of overweight. From the data obtained we calculated the percentage of weight carried and BMI of students. For analysis and interpretation of data to analyze the data, were used initially descriptive statistics as mean, standard deviation (SD) and percentage frequency (%) and later, were employed methods of inferential statistics such as t-test -test, analysis of variance (ANOVA) and Tukey test for multiple comparisons. All statistical tests were used considering a significance level of 0.05. Data were analyzed using SPSS for Windows version 10.00 (SPSS Inc.).

4. Results and discussion

Heavy school bags and excess body fat can contribute to an ever-increasing pressure on the joints and ligaments, initiating a process damaging the spine of students. New technologies are being introduced in education, such as the use of audiovisual materials, computers, software. Despite all these advances, the textbook material still remains the most useful and widespread[10].

According to Connolly et al. (2008) [3], in a comparative study of walking with backpacks in 32 children aged 12-13 years, the gait pattern was changed with a load equivalent to 15% of body mass. Pau et al. (2011) [19] evaluated 356 children aged between 6-10 years, under conditions of static posture erect, to assess the magnitude and characteristics of the effects arising from the carriage of cargo on the ground reaction force on the foot during the transport of school bags. The data collected showed that backpack load of up to 10% of body weight caused significant increases in total contact area of the foot, while backpacking with a load of 20-30% causes significant increases in plantar pressure in forefoot.

This study included 339 students aged 10 to 19 years (mean 14.01 + SD 2.12). The minimum body mass was 25.00 kg and a maximum of 105.500 kg (mean 52.16 + SD 13.04). The weight of the backpack ranged from 3.34 to 28.92% of body mass (mean 12.65 + SD 4.28) and height of individuals was from 1.35 to 1.90 m (mean 1.62 + SD 9.7) (Table 1).

Table 1
Descriptive analysis of the age, height, percentage of backpack weight and body mass for the total population evaluated

Variables	Valid N	Minimum	Maximum	Mean	Std. Deviation
age (year)	339	10	19	14,01	2,12
weight (Kg)	339	1,90	12,00	6,25	1,63
body mass (Kg)	339	25,00	105,500	52,16	13,04
height (m)	339	1.35	1.90	1.61	9,76
percentage backpack (%)	339	3,34	28,92	12,65	4,28
BMI	339	11,84	35,66	19,69	3,72

The data from these 53 students (15.33%) were classified as overweight, BMI less than 20.0 and a maximum of 35.6 (average 25.81 ± 3.4 SD). The average percentage of cargo for the population classified as overweight corresponds to (9.31 ± 3.15 SD) body mass. Of the individuals classified as overweight, 20 (37.7%) were associated with this variable excess load of the backpack. However, was not found in the literature, appropriate values of the load being carried by overweight individuals. Considering that overweight people already carry an additional charge intrinsic, it is plausible to suggest that the maximum weight for your backpack is less than 10% of body mass.

Of the total assessed, 243 (71.68%) students were carrying loads upper 10% of body mass, which corresponds to an overload (average 12.65% ± 4.28 SD). It can be observed also that the average load carried to the individuals of the total population was higher than for overweight individuals and for this sample was not observed rate exceeding 10% of body mass. These figures exceed those recommended by the WHO recommends that the weight of school supplies does not exceed 10% of body weight of elementary school children. These findings corroborate partially with Negrini et al. (1999) [16], who found an average daily load carried by 237 Italian students during the week of 12.74% of body weight; with Lopes (2002) [12], who found that the average weight carried by 563 students from the Greater Porto in Portugal was 15%; with Whittfield et al. (2005) [23], who showed that variation of weight of the backpack from 10.3 to 13.2% of body mass in 140 students from five schools in New Zealand, aged 13-17 years and wiht Moore et al. (2007) [14], which weighed 531children, aged 8-18 years, and their backpacks in northern California, and found average load carried by 11.8%.

Figure 1 represents the percentage of the backpack by age. It is observed that for all age groups tended to transport cargo that exceeds 10% of body mass. Individuals with lower age (10-11 years) tended to carry greater load percentage in comparison with older age (17-18 years). This is corroborated by Devitta et al. (2003) [5] and Costa et al. (2005) [4], and indicate that the younger the better the chance of developing postural deviations. All students aged 19 had mean values of cargo less than 10% of body mass ($p < 0.05$, $p = 0.000$).

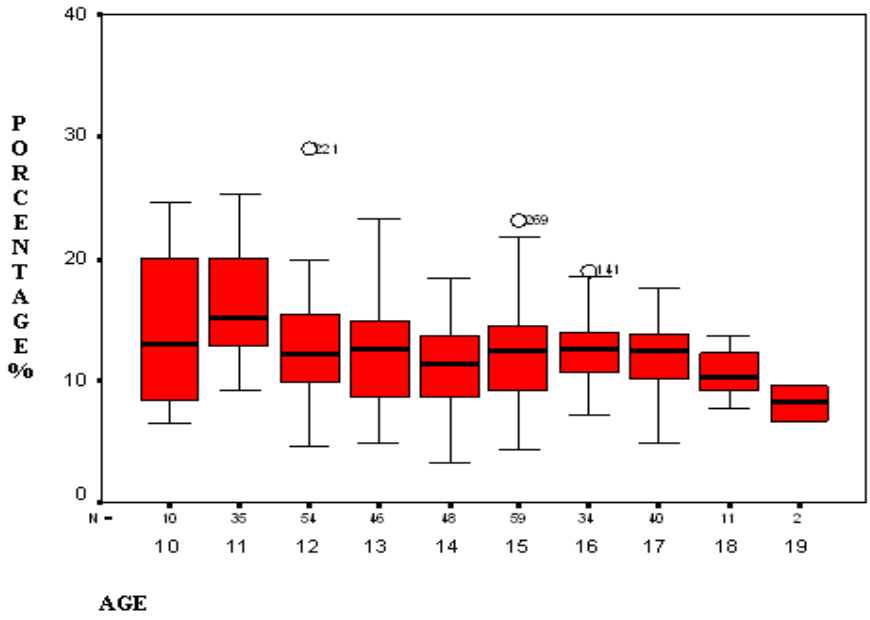

Figure 1
Relationship between percentage of the backpack and age

The Figure 2 illustrates the comparison of the percentage of backpack weight in relation to body mass, separated by sex, for the total sample.

Comparing the percentage in relation to gender, it was observed that the average percentage of the weight of the transported material in relation to body mass for females is significantly higher than males ($p = 0.000$).

These results confirm data reported by Siambanês et al. (2004) [21] and Moore et al. (2007) [14], but contrary to studies by Rebellato et al. (1991) [20] who found that the predominance of males to carry excessive load. Negrini et al. (1999) [16] also found a predominance of males to carry load more than 10% of his body weight. The same prevalence was found by Costa et al. (2005) [4] and Devitta et al. (2003) [5]. There were no data supporting this finding.

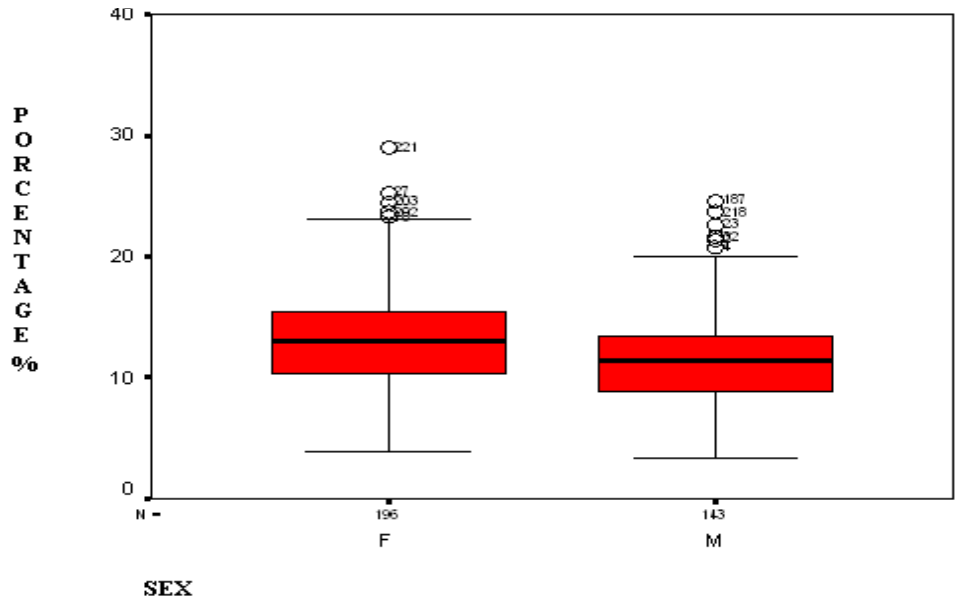

Figure 2
Percentage of backpack weight in relation to body mass, separated by sex, for the total sample

The Figure 3 represents the frequency of students with BMI classified as underweight, normal weight and overweight. 257 (75.82%) individuals had body mass of the sample within the parameters of normal (eutrophic). 29 students (8.55%) were classified as underweight and 53 (15.63%) students were in the overweight range.

Comparing the percentage of backpack weight in relation to BMI showed that the percentage of weight of the backpack is significantly higher among the population classified as underweight compared to the population overweight ($p < 0.05$).

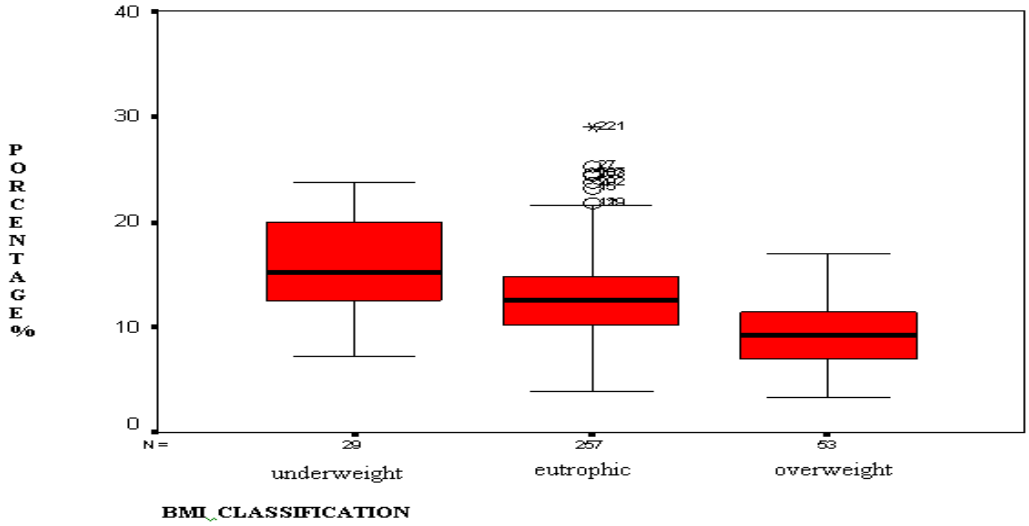

Figure 3
Relationship between BMI and percentage of the backpack

However, it was found in the literature until the year 2010, appropriate values of the load to be transported by overweight individuals.

Whereas overweight individuals already carry an additional charge intrinsic, it is plausible to suggest that the maximum weight for freight in their backpacks is less than 10% of body mass of students. In this study, the ways chosen by students, for the transportation of school supplies were in the forms of files and backpacks (dorsal and scapular fixation). Population evaluated in this study, 303 (89.38%) use the backpack design with dorsal attachment as a form of transport, 19 (5.61%) used the backpack scapular fixation model and 17 (5.01%) use the binder for the transportation of school supplies. Comparing the percentage of backpack weight in relation to the design of the form of transport of materials, it was observed that there is a statistically significant difference ($p = 0.000$): the percentage of weight of the backpack is significantly higher among the backpack dorsal attachment when compared to the binder and backpack scapular ($p < 0.05$).

Grandjean and Kroemer (2005)[7] reported that students carry school supplies in one hand have an energy expenditure greater than twice those who carry the material in a backpack. This increase in power consumption should be attributed to static work arms, shoulders and trunk.

Rebelatto et al (1991) [20], also observed that children carrying school supplies with the use of backpacks to carry out fixing dorsal, does anterior trunk flexion with increased demand from the lumbar musculature and the level of compression at L5-S1 intradiscal and , those who use backpacks to carry out fixing scapular lateral inclination of the trunk with intradiscal less compression compared to the dorsal attachment. However, both can determine localized pains due to metabolic and tensional changes of the muscles of the spine.

According to Noone et al (1993) [7], the transport of an asymmetric external load, during a significant time for children and adolescents, would be one of the factors contributing to the emergence of scoliotic curves. Of the population represented in this study, 71 (21%) students, aged 11 to 19 years (mean 14.22 ± 2.20 SD), complain of back pain and shoulder, with a minimum of two and maximum of 72 months (mean, 2.66 ± 6.97 SD) of onset of symptoms. In this context, 52 (73.2%) were females and 19 (26.8%) males. When comparing the complaint of pain in relation to gender, this was statistically significant for females than males ($p = 0.003$). However, comparing the percentage of the backpack and age for the presence of the symptom of pain was observed that there was no statistical significance between the presence or absence of pain ($p = 0.361$). It should be noted, though, the fact that most students, although these relate to transport muscle aches from their backpacks, denote a more or less resigned before this reality. Of the students who showed symptoms of pain, only 11 (15.5%) had previously made in relation to medical abuse of these, four (36.4%) were in physiotherapy and orthopedic treatment for scoliosis.

Recent studies have identified also that the load carried in school bags, can be a risk factor for the onset of back pain in children and adolescents, and that this symptom can last into adulthood [8 ,9, 13, 19]. In this study it was found also that 128 (37.7%) students carried out on foot to de-displacements home / school / home while 211 (62.3%) do so through vehicles (car, van or bus). There is a relationship of magnitude between itinerary and weight of school supplies. Comparing the percentage of the bag over the route used by students, it was observed that students who perform the journey on foot had mean load, significantly higher than students who use vehicles ($p = 0.003$). When comparing the means of locomotion for the presence of pain was observed that there is a statistically significant ($p = 0.000$), as the complaint of pain, among students who perform the journey on foot, is significantly higher than those who do so through vehicles. These data confirm the findings by Siambanes et al. (2004) [21] that documented the presence of pain in relation to the means of locomotion, walking to school / home / school, 43% of their total sample. Hestbaek et al. (2006) [9] conducted a prospective study of eight years of follow-up to 9600 Danish twins, whose objective was to describe the evolution of low back pain from adolescence to adulthood. The authors report a correlation between low back pain in childhood adolescence and the same persistence in adulthood.

5. Conclusion

The present study found that 71.68% of the subjects had values of cargo carried in school bags over 10% of his body weight. 15.33% of the sample was classified as overweight, according to parameter calculation of BMI by age and gender of the reference National Health and Nutrition Examination Survey (NHANES). 37.7% of individuals classified

as overweight carry school bag weighing over 10% of his body weight.

Excess cargo and the change in BMI are risk factors for postural complications. 21% of the population studied reported complaints of back pain and shoulder, with a mean onset of symptoms of 2.6 months. 36,4% of population with complaints of pain were in orthopedic and physiotherapic treatment to control the scoliosis. Growth is a dynamic and a continuous process throughout childhood and adolescence. The use of anthropometric indicators, according to Ministry of Health, is considered one of the best parameters to assess and monitor children's health. These data has great importance in the preventative aspect for the population studied, as well as others of the same age, so that they can be advised on the removal of these risk factors. This study may provide knowledge about the variables that may be acting on the spine of school children, allowing for future studies and expanding the role of the ergonomist and designer in this area.

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