

COMPARISON BETWEEN TWO DIFFERENT TYPES OF SCHOOL BAGS AND MUSCULOSKELETAL SYMPTOMS IN PRIMARY SCHOOL STUDENTS

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Abstract The subject of this research was to find out the relationship between the school bag (trolley bags and shoulder bags) and the appearance of musculoskeletal symptoms in Greek primary school pupils, as well as to discuss ways in which these symptoms can be avoided. The sample consisted of 199 primary school children, aged 7-12 years old. Also, questionnaires answered by their parent-guardians and the educational staff of the school where the survey was conducted. The measuring tools used were questionnaires, measuring tape, electronic scale and electronic dynamometer. The results indicated that the 60.8% of children, regardless of the type of bag, reported some musculoskeletal pain during the transfer of the school bag, with pupils with a shoulder bag showing 65.3% musculoskeletal pain and 42.9% of those with trolley bag showing musculoskeletal pains. However, students with trolley bags carry heavier bags, than the pupils with shoulder bags, and the ratio between the body weight and the bag weight of the pupils in all classes exceed the 10% suggested by the literature. Findings made during this study suggest that children, parents and teachers should be trained on the characteristics of the school bag and its safe transport. Parents should have a more active role in promoting safety and should represent the team that will most likely help to significantly reduce the damage associated with carrying the school bag, choosing safe school backpacks, supervising the contents of the bag and checking its weight.

Keywords : School bag; musculoskeletal symptoms; primary school.

1. INTRODUCTION

There are several studies mentioning that pupils have musculoskeletal problems due to the wrong use of their school bag. Many times students perceive the daily transfer of their school bag as a process that causes them great discomfort [1]. This discomfort, combined with the fact that often, when parents buy a backpack for their child, do not pay attention to the design of the backpack, the investment it has, its total weight, but also other parameters such as the things that the child transports and the way child did it [2], exacerbate the child's discomfort, resulting in fatigue and musculoskeletal pain [1]. In addition, studies show that parents and teachers are also poorly informed about school bag issues [3]. Over 50% of the parents didn't know the recommended weight limit of the school bag and nearly two thirds of them, had no information about the correct size and how the child must carry his schoolbag. However, the occurrence of musculoskeletal pains in pupils seems to be factorial issue, because except the weight of the school bag, psychosocial factors are also involved [4]. In many studies, it is proposed a weight of 10% of the child's body weight as the maximum weight of the school bag [5]. However, there is a general disparage about this percentage, as in the guidelines for pupils this percentage ranges between 5-20% [6]. A school bag that exceeds this limit

has been implicated in the appearance of musculoskeletal problems in students. A greater appearance of musculoskeletal problems occurs when the weight of the bag exceeds 10% of the child's body weight, with the most significant muscle changes occurring when backpack weight corresponding to 20% of the body weight of the child [7]. Many studies concluded that younger students carry heavier bags than larger class students and girls have heavier bags than boys [1,5]. These observations are not absolute as the weight of the school bag can be influenced by other factors such as the child's class, school bag type, day of the week, child's body mass index, race, ethnicity etc. [9]. A common feature among all surveys is that a very large percentage of students carry a bag that exceeds the weight of the proposed 10% of body weight. Studies conducted over the past twenty years show that a very large part of the student community carries bags that exceed the recommended 10% of the body weight. 34.8% of Italian pupils carry backpacks with weight that exceeds 30% of their body weight, at least once a week [10]. Another study among 345 elementary school children reported that 55% of the sample had a school bag weighting more than 15% of their body weight [11]. Two studies carried out in central Texas and Ohio respectively, showed that twenty-six per cent of elementary school pupils had school bags weighing at least 10% of their body weight [9,2]. In a similar study in New Zealand [12] the average weight of children school bags exceeds 10% of their body weight. A survey carried out in Poland among 108 pupils concluded that about 78.3% of the first-grade pupils, 43.3% of second-grade pupils and 40.0% of third-grade pupils had backpacks weighted over 10% of their body weight [13]. A descriptive study among 532 students from six elementary schools in Uganda [14], showed that about 30.8% of students wore school bags that were over 10% of their body weight. In a research among 916 pupils in Brazil [15], it was observed that 59.06% of school bags exceeded 10% of the body weight of children. The findings from a descriptive-analytical study conducted in 2015 in Abadan, Iran, showed that 36.9% of pupils in public schools and 55.1% of pupils in private schools were wearing backpacks overweight 10% of their body weight [16]. Carrying a load of 10% of body weight seems to be directly related to the occurrence of musculoskeletal symptoms in children. As [17] reported, despite the fact that the load carried by the children was within the current weight limit of 10% - 15% of the child's body weight, the prevalence of musculoskeletal problems was very high among the study population. About 35.4% of the children reported that transferring their school bag was the cause of their musculoskeletal pain [14].

[1] report that school backpacks are considered heavy by 79.1% of children, however fatigue during transport and the time that the child carries the school bag are the factors associated directly with back pain rather than the weight of the backpack. In children carrying a shoulder strap bag weighing more than 10% of their body weight, an increase in torso rotation as well as an increase in the angle of the kyphosis is observed [18]. Results from other studies suggest that wearing a backpack heavier than 10% of the body weight can cause a reduction in lumbar lordosis and a tendency for the sacrum bone to come to a vertical position [19]. In another study [20], the results show that the backpacks weighing more than 10% of the body weight and their transport time are causing a deterioration in the attitude changes, placing children at increased risk of injury and pain. Apart from the above, a school bag weighing more than 10% of body weight increases the prevalence of shoulder drops, kyphosis and lordosis in elementary schoolchildren, factors that may endanger their physical health [16]. The transport of a charge corresponding to more than 10% of body weight affects the spinal kinematics at all levels and movements [23]. Apart from musculoskeletal changes, the use of a school bag whose weight exceeds 10% of body weight leads to reduced lung capacity, with the consequences being greater as the weight of the bag increases [22]. We should not forget that children spend more time in schools during the critical development stages of their lives. Everyone feels that schools are safe places, but they are not, as many ergonomic hazards have been identified in school environments.

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There are important mismatches between anthropometric measurements and school furniture, heavy school bag and various types of handbags. Negative effects range from general fatigue, musculoskeletal pain, spinal deviation, shoulder changes, injuries, and psychological disorders. Various studies have signaled that it is not enough to make a right choice of the school bag, but also to properly adapt it to the child's body. The most common type of school bag used is the shoulder bag with 2 straps, but the majority of students do not make adjustments to them [23]. Incorrect adaptation to the straps of the school bag has a significant effect on increased rotation in the upper thoracic spine and also has an influence on the reduction of lumbar lordosis [18]. On the other hand, using a bag with 2 straps properly attached to the child's body can help reduce the muscular activity of the trunk muscles, which in turn can reduce the reports of musculoskeletal pains to the pupils [24]. Parents are the best supporters of promoting children's health and should represent the team that would probably help significantly reduce the injuries associated with children's backpack by selecting safe school backpacks by supervising the school backpack and controlling the weights of the backpacks [3]. It is important to note that students who received ergonomic instructions reported significant improvements in reducing the weight of the school bag [25], and also must be mentioned that the pupil's preference for the backpack can change from the moment he will look for it for the first time in relation to the same backpack when using it in the future [26]. For this reason, parents, pupils and school staff should be informed about these issues and there should be appropriate information on the purchase and use of school bags [23]. In recent years trolley school bags have appeared, but investigations into their usefulness are limited. In 2003, only 3.5% of students (25 students) used a trolley bag among 714 primary school students in Ohio [9]. One problem with trolley bags is that children may have a false sense of security with these type of bag and as a result they carry more weight. In addition, "students with wheeled backpacks were 14 times more likely to carry heavy loads than those who used backpacks without wheels" [2]. Recent studies have dealt with the kinematic changes of students when carrying a trolley bag [27]. The results show that the transfer of a school backpack have greater changes in the kinematic analysis of the pace compared to the transfer of a trolley bag and concluded that the transfer of a school trolley bag with a weight corresponding to 15% of the body weight of children is more akin to not carrying a bag while walking than to carry a shoulder bag with the same load. The kinematic adaptations that the child adopts when it transfers a trolley bag, are minimal and trolley bags could be considered a good option for use in the transport of school supplies [28].

2. METHODS AND MATERIALS

The aim of the research was to investigate the relation between the occurrence of musculoskeletal symptoms and the type (trolley bag or shoulder bag), the size and the weight of the school bags among the six grades of elementary school students in Greece. The study protocol was approved by the Bioethics Committee of the Alexander Technological Institute of Thessaloniki and the Institute of Educational Policy, under the protocol number $\Phi 15 / 30405/61325 / \Delta 1$. The sample consisted of 199 primary school children, aged 7-12 years old. Also, questionnaires answered by their parent-guardians and the educational staff of the school where the survey was conducted. The measuring tools used were questionnaires, measuring tape, electronic scale and electronic dynamometer. Data collection were carried out on unscheduled days in order to, children and their parents prepared school backpacks based on their own previous habits and behaviors. To ensure the consent of the participants to the survey, their anonymity in the research and the protection of their sensitive personal data according to the legislation in force, the possibility of the participants to

interrupt at any stage of the research and their protection from exposure to possible physical or psychological danger, are ensured by the signed consent form of the parents and guardians of the students, which is extensively referred to how to ensure all of the above. For the statistical analysis of the data, the statistical package for IBM SPSS (Statistical Package for Social Sciences) version 23 was used. For the summary of the results, absolute and relative frequencies (percentage %), central stresses (averages, median values) were calculated. Statistical analyzes were also performed with non-parametric statistical criteria. For the comparison of groups with unrelated values the following tests were performed: Mann-Whitney U Test, Kruskal-Wallis H Test and X^2 Test. The Spearman's ρ correlation coefficient was also calculated and the level of significance of all statistical controls was predetermined at $\alpha = 0,05$.

3. RESULTS AND DISCUSSION

3.1 General findings

Among the 199 pupils surveyed, 102 were boys and 97 girls, of whom 40 were from 1st Grade, 23 from 2nd Grade, 29 from 3rd Grade, 35 from 4th Grade, 36 from the 5th Grade and 36 from the 6th Grade. Most of them (45.7%) carried a trolley bag and 37.7% of them carried a shoulder bag, with the rest 16.6% of the sample not answered. When students were asked if they feel pain when carrying their school bag, 60.8% of the sample reported some musculoskeletal pain, most of which reported pain in the shoulders (28.6%), the lumbar spine (5.5%), elbow (4.5%), wrist (4.0%), thoracic spine (1.6%) and the rest 16.6% did not mention the exact point of their pain. 19.1% of students reported that the pain was in the last 3 days, 19.1% over 7, while only 6% of the sample reported that it hurts for 3-7 days, the rest 16.6% did not mention the exact period of their pain. The majority of students who reported some musculoskeletal pain answered that pain is more acute when they carry the school bag (36.7%), as opposed to a smaller percentage (7%) who answered that the pain is stronger in the night. Pain intensity was evaluated by the Wong-Baker FACES® Pain Rating Scale and reported as moderate intensity (2-6) by the bulk of students (37.7%). Nearly 25% of our sample responded that it carries all their books daily and 72.4% of the children answered that they carry every day in their school bag other things like food, water, clothes, umbrellas, toys, etc. The 47.7% of the children replied that they carried their bag easily, while 35.7% carried it difficulty and the rest 16.6 of the sample did not answer. In addition the 54.8% of students feel the school bag heavy when carrying it, while only 28.6% feel it light and the rest 16.6 of the sample did not answer. In comparisons made, there was no significant difference in the choice of the bag in relation to gender. Instead, we see that students of the lower grades (1st-2nd grade) prefer trolley bags in relation to older students (5th – 6th grade) who prefer shoulder bags. In middle-class students (3rd – 4th grade) the percentages are shared. In relation to the point of occurrence of pain, it was observed that pupils with a shoulder bag in their majority report pain in shoulders (54.7%), lumbar spine (6.7%), thoracic spine (4.0%) and 34.6% did not mention any pain, while those with trolley bags only 17.6% reported pain in shoulders, the elbow 9.9%, wrist 8.8%, lumbar spine 6.6% and 57,1% did not mention any pain. In terms of pain intensity and type of bag, the pain appears to be of the same, moderate intensity. As for the size of the school bags, there was no significant difference between the two types of bag being studied.

3.2 Questions to parents

When parents asked about the reason they choose that bag for their child, the majority of them (64.8%) answered that the schoolbag was chosen by the child, despite 58.8% of them reported that have a relative information on the proper use of the school bag and the dangers it may have. Another contradiction is that 60.8% of children show some musculoskeletal pain while carrying their school bag, only 19.6% of parents know about it. In another question about the weight of the bag, the majority of parents (51.3%) believe that the school bag weights more than 5 kg, while 44.7% said it weights 3-5 kg, with the average weight of the bag to be 5,92kg for the trolley bags and 5,10kg for the shoulder bags. The content of the school bag is controlled by parents in 92.5% of the cases studied, with 59.3% of the parents checking it daily, 22.1% 2-3 times a week and 15.6% once a week. Last question to parents about their opinion whether the desks and chairs meet the demands of the children, 65.3% of the parents answered that they did not respond, while 34.7% answered that they responded.

3.3 Comparisons between all the children

In comparisons made between all children statistically significant differences were observed between the type of bag and the existence of pain. Most of the students who have a trolley bag have no pain (57.1%) against the pupils with shoulder bags where 65.3% of them reported pain ($X^2 = 8.34$, $p < 0.004$).

Table 1. Pain existence due to the type of bag.

Pain existence * Bag type Crosstabulation				
PAIN EXISTANCE		BAG TYPE		Sum
		TROLLEY	SHOULDER	
YES	N	39	49	88
	% due to bag type	42,9%	65,3%	53,0%
NO	N	52	26	78
	% due to bag type	57,1%	34,7%	47,0%
Sum	N	91	75	166

Also statistically significant differences were observed with respect to the duration of the pain and the type of the bag.

Table 2. Pain duration due to the type of bag.

Duration of the pain (days)		
Bag type	Mean	N
Trolley bag	0,90	91
Shoulder bag	1,25	75

Pupils with a trolley bag reported that the pain has a slightly shorter duration (Mean = 0.9) than the pupils who have a shoulder bag (Mean= 1.25) ($U = 2745.5$, $p < 0.02$). Also, statistically significant differences were found with regard to the type of bag and the intensity of pain, with students having a

trolley bag, the pain has a lower intensity (Mean = 1.36) than the pupils who have a shoulder bag (Mean = 2.05) (U = 2695, p<0.02).

Table 3. Intensity of pain due to the type of bag

Pain intensity		
Bag type	Mean	N
Trolley bag	1,36	91
Shoulder bag	2,05	75

Our results showed that the majority of students with a shoulder bag (85.3%) carry only the books of the day, in comparison with the 39.6% of students with trolley bags who carry all their books daily ($X^2 = 12.55$, p <0.001).

Relationship was also been found between the type of bag and body mass index (BMI). In particular, students with a trolley bag have a lower body mass index (Mean = 17.73) than those who have a shoulder bag (Mean = 18.61) (U = 2367.5, p <0.02). Statistically significant differences were also observed in relation to the weight of the bag and its type. Students with trolley bags carry heavier bags (Mean = 5,92kg) than those who have a shoulder bag (Mean = 5,10 kg) (U = 2043, p<0.001).

Table 4. Mean of bag weight for each type of bag.

	Bag type	N	Mean
Bag Weight (kg)	Trolley bag	83	5,92
	Shoulder bag	74	5,10

There were statistically significant differences based on the existence of pain as to whether students carry their bag easily or difficulty, but also if they feel it heavy or light. The 70.5% of students who suffer musculoskeletal symptoms when carrying their bag, reported that their school bag was difficult to carry, while 88.5% of students who did not suffer any musculoskeletal symptoms when carrying their bag answered that their schoolbag was easy to carry ($X^2 = 58.64$, p < 0.001).

Among the students who feel any pain when carrying the schoolbag, 88,6% of them reported that they felt their bag heavy, while 60.3% of students who did not feel any pain answered that they felt the bag light ($X^2=43.84$, p <0.001).

Statistically significant differences were also observed in relation to the students' complaints to the parents about pain during carrying the bag and whether they carry the bag easily or hardly. Among students who complain about pain when carrying the bag, the 60.6%of them said that the transfer seemed difficult. Instead, students who do not complain about pain during carrying the bag, the 61.7% of them said that carrying the bag seemed easy ($X^2 = 5.35$, p <0.03).

Differences were also found with regard to the frequency of bag check by parents and the appearance of pain when carrying the bag. Parents of students who complain about pain, control the bag less

frequently (Mean = 2.05) than parents of students who do not complain about pain (U = 2.46) (U = 2349,5, p< 0.007).

Table 5. Bag control frequency from parents due to children complaints about pain.

Bag check frequency		
Complaints about pain	Mean	N
Yes	2,05	39
No	2,46	160

By analyzing the ratio of body weight to bag weight, we found statistically significant differences for the last three grades (4th grade U = 79, p<0,05, 5th grade U = 22, p<0,003 and 6th grade U = 20, p < 0.03).

Table 6. Mean weight of children carrying trolley bags and mean weight of their bags.

Grade	1 st	2 nd	3 rd	4 th	5 th	6 th
N	21	15	16	16	10	5
Mean children weight (kg)	24,65	33,05	30,97	36,2	38,33	39,44
Mean weight of trolley bags (kg)	5,04	5,02	6,67	5,88	7,67	5,79

Table 7. Mean weight of children carrying shoulder bags and mean weight of their bags.

Grade	1 st	2 nd	3 rd	4 th	5 th	6 th
N	7	2	9	17	17	2
Mean children weight (kg)	26,87	26,95	31,29	36,81	39,9	45,29
Mean weight of shoulder bags (kg)	4,25	3,97	5,95	4,74	5,72	4,94

Table 8. Ratio between body weight and weight of bags.

Grade	Trolley bags		Shoulder bags	
	N	Percentage %	Percentage %	N
1 st	21	20,60	16,80	7
2 nd	15	15,88	14,54	2
3 rd	16	22,76	19,16	9
4 th	16	17,28	13,65	17
5 th	10	20,41	14,53	17
6 th	5	14,84	11,09	22

Specifically for the last three grades, the percentage is higher for students with trolley bags than pupils with shoulder bags. More specifically, for the 4th grade, students with trolley bags have a body weight-bag weight ratio of 17.28% compared to those with shoulder bags, at 13.65%. For 5th grade, students with trolley bags have 20.41% body weight-bag weight ratio, as opposed to those with shoulder bags, with 14.53%. Finally, for the 6th grade, students with trolley bags have a body weight – bag weight ratio of 14.84% in contrast to those who have shoulder bags, with 11.09%. In the first three grades there were no statistically significant differences (it should be considered in a larger sample), but in all cases the ratio exceeds the proposed 10% reported in the bibliography. For 1st

grade, students with trolley bags have 20.06% body weight-bag weight ratio as opposed to those with shoulder bags, with 16.8%. For 2nd grade, students with trolley bags have a 15.88% body weight-bag weight ratio, compared to those with shoulder bags, with 14.54%. For 3rd grade students, those with trolley bags have a body weight-bag weight ratio of 22.76% compared to those with shoulder bags, at 19.16%.

3.4 Comparisons between the children who suffer any musculoskeletal symptoms when carrying their bag

In comparisons made between children experiencing pains, there were statistically significant differences based on the type of bag and the books they carry. More specifically, from pupils with pains, those who have a shoulder bag in their majority (85.7%) carry only the books they need for each day, against the 59% of the students with trolley bags ($X^2 = 8.04$, $p < 0.005$). Also statistically significant differences were observed based on the type of bag relative to the body mass index. Of the students experiencing pains, those with a trolley bag have a lower body mass index ($M = 17.73$) than those who have a shoulder bag ($U = 18.61$) ($U = 512.5$, $p < 0.003$). In addition, statistically significant differences were found based on the type of bag relative to the weight of the bag. Among the students who suffer musculoskeletal symptoms, those with trolley bags carry a heavier bag (Mean = 6,06kg) than the pupils who have shoulder bags (Mean = 5,31kg) ($U = 581$, $p < 0.02$).

3.5 Class-based comparisons

In class-based comparisons there were statistically significant differences based on the class and the period the child felt the pain ($H = 17.98$, $p < 0.004$).

Table 9. Period of pain when children carrying their bags for each grade.

Period of pain (days)	Grade					
	1 st	2 nd	3 rd	4 th	5 th	6 th
Mean	2,35	1,67	2,60	1,75	2,05	1,39
N	17	6	15	12	20	18

Among the students who suffer any musculoskeletal pain, those of the 6th grade suffer for a shorter period of time (Mean = 1.39) compared to those of the 2nd grade (Mean = 1.67) and 4th grade (Mean=1.75), much smaller than those of 1st grade (Mean = 2.35) and for much less than those of 5th grade (Mean = 2.05) and 3rd grade (Mean = 2.60) that feel pain for a longer period of time. In addition, statistically significant differences were observed based on the grade and pain intensity ($H = 18.01$, $p < 0.004$).

Table 10. Children pain intensity when carrying their bags for each grade.

Pain intensity	Grade					
	1 st	2 nd	3 rd	4 th	5 th	6 th
Mean	3,71	3,17	3,67	3,25	3,00	2,33
N	17	6	15	12	20	18

Among the students who suffer musculoskeletal symptoms, those of the 6th grade (Mean = 2.33) suffer less pain than those of the 5th, 2nd and 4th grades (Mean= 3,3,17 and 3.25 respectively) and quite less

than those of the 3rd and 1st grade (Mean = 3.67 and 3.71). Still, statistically significant differences were observed based on the class in order of the bag control frequency ($H = 22.34$, $p < 0.001$).

Table 11. Bag check frequency from parents for each grade.

Bag check frequency	Grade					
	1 st	2 nd	3 rd	4 th	5 th	6 th
Mean	2,94	2,83	2,47	1,92	2,10	1,72
N	17	6	15	12	20	18

More specifically, from the pupils who suffer any pain, the parents of the 1st grade pupils control almost every day their child's bag (Mean = 2.94) and more often than in the 2nd grade (Mean = 2.83), slightly more frequent than those of 3rd grade (Mean = 2.47), more often than those of the 5th and 4th grade (Mean= 2.1 and 1.92 respectively) and much more often than those of 6th grade (Mean= 1.72), who control it about once a week.

Finally, there were statistically significant differences based on the class, relative to the weight of the bag ($H = 27.13$, $p < 0.001$).

Table12. Bag weight in each grade.

Bag weight (kg)	Grade					
	1 st	2 nd	3 rd	4 th	5 th	6 th
Mean	4,71	5,00	6,50	5,43	6,55	5,04
N	15	6	15	12	18	17

Among the pupils who suffer musculoskeletal pain, those of the 5th and 3rd grade carry a heavier bag (Mean = 6,55kg and 6,50kg respectively) compared to those of the 4th grade (Mean = 5,43kg), quite heavier than those of the 6th and 2nd grade (Mean = 5,04kg and 5,00kg respectively) and much heavier than those of the 1st grade (Mean = 4,72kg).

4. CONCLUSION

From the analysis of the data, as well as from references in the literature, it is clear that the prevention of musculoskeletal problems caused by the schoolbag in primary school pupils is a serious problem. Parents, pupils and educational staff must have better information about risks carrying of an overweight school bag. Another highly importance point is that parents should have more active - advisory role when purchasing the school bag. Backpacks with straps for shoulders, or trolley bags must be preferred and shoulder bags with one strap and carrying the 2-strap bag on one arm must be avoided. On the other hand, the choice of a 2-strap shoulder bag not solve the problem if the bag straps not be adjust to the child requirements. Our results shown that trolley bags seems to be safer and they should preferred more frequent than shoulder bags, but due to the lack of research about them, more studies must be done before we are absolutely sure about their safety. Parents also should check the school bag frequently and be more interested about the musculoskeletal pains their child may have when carrying the school bag. The conveyance of the school bag by parents wherever possible to reduce the bag transport time by the child is also another idea. Avoiding the carriage of stuff not needed inside the bag will reduce its weight, but at this point both parents and students must pay attention to the weight of trolley bags as the feeling of easier transportation, making them a trap

for making them heavier. Finally educational staff should advise students to carry only as many books as they are useful for each day and the rest leave either at school or at home, advise parents at regular intervals for risks of the overweight bag and inform them about child's observations of "heavy bag" and musculoskeletal symptoms they mention them.

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