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The association between grade, gender, physical activity, and back pain among children carrying schoolbags

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Objective: To examine the association of age, gender and physical activity levels with the occurrence of shoulder, neck, upper back and lower back pain while carrying schoolbags. ***Methods:*** Six hundred fourteen boys (N = 293) and girls (N = 321) between 1st and 9th grade (age: 6-14 years) participated in this study. The study analysed pain symptoms while carrying schoolbags, student perceptions of schoolbags, physical activity levels, schoolbag weight and anthropometric characteristics. Logistic regression models were used to examine how the recorded factors contributed to the occurrence of pain and interacted with one another. ***Results:*** More than half of the students reported body pain when carrying their schoolbags. Of these, 25.9% reported pain in their necks, 50.3% in their shoulders, 37.5% in their upper backs, and 20.8% in their lower backs. Girls experienced pain more frequently (x2 = 18.743) than boys. Grade, gender and schoolbag weight did not contribute to pain. In contrast, higher physical activity levels were associated with lower pain incidents (p <0.05). Students who felt fatigued while carrying schoolbags had a 2.455 (95% CI = 1.489-4.046) times greater chance of experiencing pain than those who experienced no fatigue. Girls after 5th grade were 1.161 (95% CI = 0.974-1.384) times more likely to develop pain than boys of the same age. Girls with low physical activity levels had a 3.170 (95% CI = 2.409-4.171) times greater chance of reporting pain as compared to more physically active boys. ***Conclusions:*** Pain when carrying schoolbags is a significant problem in schoolchildren. Low levels of physical activity and high fatigue levels are significant contributors to pain experienced by children when carrying schoolbags, and the problem is more intense in girls and in older children.

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Key Words: gender; pain occurrence; physical activity; schoolbag use

INTRODUCTION

Developing back pain at an early age is a significant risk factor for experiencing back pain in adult life (14). Research has shown that the percentage of children and adolescents who suffer from back pain varies between 11% and 52.1% (26). Consequently, it is worthwhile to examine the factors which contribute to pain among children.

One factor which might contribute to pain in children is overloaded schoolbags. There is evidence that heavy backpacks carried by students can cause altered gait and bad posture (6, 15, 33). Based on this evidence, the American Academy of Pediatrics has recommended safety limits ranging from 10% to 20% of body weight (BW) for schoolbags (1). Despite these recommendations, research findings on the association between pain and schoolbag weight are conflicted, as some studies have reported that students who carry heavier bags are more likely to experience back pain (11, 29, 34, 37, 39-40, 43) while others have found a non-significant association (10, 17, 21-22, 30, 42). A limitation of these previous studies is that students have typically been asked to report current pain or pain history rather than pain while carrying their schoolbags (10, 16-17, 21-22, 30, 34, 42-43). This could lead to an underestimation of the association between schoolbag weight and pain (29).

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One may hypothesise that pain characteristics among younger children may differ as compared to those among older ones, due to differences in physical capacity, physical activity style, growth effects and schoolbag weight characteristics. Since children are grouped in school classes (grades) based on their chronological age, their school-related activities are specific to their grade and, to some extent, their age. However, research findings on the association between back pain and age are not entirely consistent. Most studies show that older students experience pain more often (3, 5, 12, 34, 39), while Goodgold et al. (10) have reported no significant association between age and pain occurrence, probably because the age range of their sample was narrow (11-14 years). Even if age does not have a clear association with pain development, school grades might have an effect on pain development when walking with the schoolbag, making it worthwhile to examine pain development as the school grade increases.

Studies have shown that back, neck, and shoulder pain problems are more intense in girls than in boys (22, 30, 37, 42-43). Some suggest that these gender differences are due to various factors such as differences in schoolbag weight, the mode of carrying schoolbags, the amount of time carrying schoolbags, rate of growth and physical activity (11, 19, 34, 39). Gender differences in schoolbag pain development and its associated factors have not been thoroughly examined. If there are differences in pain determinants between boys and girls, then it would be necessary to develop and promote gender-specific interventions for schoolbag use safety.

As suggested above, grade and gender may be determinant factors of pain among children carrying schoolbags. To our knowledge, previous studies (11, 21-22, 29, 37, 39) have examined the role of various factors (e.g., gender, age or schoolbag weight) independent of one another. Since growth and maturation rate differ between genders (27, 41) it may be hypothesized that gender differences in pain could be age-specific. Grimmer et al. (13) provided some evidence that the relationship between peak height velocity and cranio-vertebral angle differs between boys and girls. Likewise, in the case of school bag-related pain, examining the interaction between grade and gender effects may provide additional insight into the mechanisms of pain development in school children.

Physical activity is another factor which may contribute to pain in schoolchildren (28, 30-31). There is evidence that high levels of physical activity may increase the risk for low back pain (23). However, pain development in childhood has also been attributed to low levels of physical activity owing to a sedentary lifestyle, particularly in girls (14, 28, 30-32, 36). Whether this is true for pain during schoolbag transfer is not clear. Furthermore, if physical activity levels differ between genders, then this could provide an additional explanation for the higher levels of pain among girls than among boys. In fact, taking into consideration the effects of age and differences in the curriculum activities based on school grade, it is interesting to examine the interaction of all three factors – physical activity, grade and gender – on schoolbag-related pain.

The purpose of this cross-sectional study was to examine a) pain and schoolbag use differences between boys and girls while carrying their schoolbags; b) grade differences in pain and schoolbag use from early childhood to puberty; c) the association between physical activity and pain, both as a single factor and in combination with grade and gender; and d) the interactive effect of grade and gender on pain while carrying schoolbags.

METHODS

Students from five primary schools (1st – 6th grade, aged 6-11 years) and three secondary schools (7^{th} – 9^{th} grade, aged 12-14 years) participated in this study. The National Pedagogy Institute and the University Ethics Committee approved the measurement protocol. A description of the study's procedures was provided to parents, and written parental consent was obtained prior to participation. Out of the 980 students invited to participate in the study, parental consent was obtained by 732 of them.

Data were collected during a typical day at school so that actual schoolbag weight could be recorded. Height was measured to an accuracy of 0.5 cm using a portable stadiometer, and standing height was measured with the student barefoot (25). Body and schoolbag weight were measured with electronic scales with an accuracy of ± 0.1 kg. To ensure reliability of the protocol, the weight measurements were taken on the same day and by the same investigator, and the average value out of three measurements was recorded. With this data, each student's BMI was estimated in kg/m^2, and the relative schoolbag weight was estimated as a percentage of student weight (% of BW).

Questionnaire

After weighing, students completed a questionnaire consisting of open-ended, close-ended, and branching questions. The questionnaire consisted of four sections. The first section included questions regarding the characteristics of schoolbag use (type of schoolbag, method and duration of walking with the schoolbag) (20). The second section, adapted from Negrini (31), included the following questions about student perceptions of the schoolbag: "During the past

4 weeks, do you usually get tired while carrying your schoolbag?" (yes-no); "How often does it happen?" (sometimes, often, always); "During the past 4 weeks, do you usually think your schoolbag is heavy while carrying it?" (yes-no); and "How often does it happen?" (sometimes, often, always).

The third section of the questionnaire was based on a validated questionnaire by Salminen et al. (36), and it asked children to recall the number of hours of systematic participation (practice and sport performance) in physical activities per week and the type of physical activity for the past year. The last part of the questionnaire, which was based on a previously validated questionnaire (24, 43), evaluated pain while carrying the schoolbags. A picture of the upper human body with four body regions (neck, shoulders, upper back and lower back) was provided (Figure 1). Students responded either yes or no to the question, "During the past 4 weeks, have you had pain while carrying your backpack?" Those students who reported pain had to specify in which region/s they had experienced it. A recall period of one month was used because pain questionnaires requiring recall periods longer than one month yield unreliable information (37). Confidentiality was ensured during the experimental session.

In a pilot study, the questionnaire was re-distributed to 90 randomly chosen students on a separate day. The test-retest reliability was determined using the Intraclass Correlation Coefficient (ICC). The ICCs varied from 0.79 to 0.99, indicating acceptable reliability (38).

Statistical Analysis

The students were divided by class level (years 6-14) rather than chronological age, based on curriculum requirements specific to each school year level (11). Pearson's analysis showed that the correlation coefficient between school years and chronological age was r = 0.82. The sample was divided into students who carried bags heavier than 10% BW and those who carried bags less than 10% BW. For categorical variables, group differences were examined using chi-square tests.

Following data collection, the sample was divided into children with and without pain. This was performed using pain results for each of the four body regions assessed. In addition, children were also classified as pain or pain-free, depending on whether they experienced pain in any of the four body regions. Thus, five data sets regarding pain were used in the subsequent analyses.

Data were first checked for normality using a Kolmogorov-Smirnov test and then for homogeneity using Levene's test for quality of variances. Subsequently, a two-way analysis of variance (ANOVA) was applied to examine the differences, in hours, of physical activity per week between boys and girls with and without pain. Separate ANOVA tests were applied for children with and without region-specific pain. For each significant F-ratio, the eta-squared values (η^2) were also calculated as a measure of effect size. Effect size values were characterised as proposed by Cohen (8), where values less than 0.01 indicated a small effect, values less than 0.06 a medium effect and values less than 0.14 a large effect.

A multinomial logistic regression was performed to determine which factors contributed to the occurrence of pain while carrying a schoolbag. Since pain was assessed in four separate regions, a separate regression model was applied for each region. In addition, a fifth regression model was used to examine pain occurrence, irrespective of the region of pain. In each model, the input variables were grade, gender, BMI, schoolbag weight, duration of walking with schoolbags, physical activity, relative schoolbag weight, type of schoolbag, method of carrying the schoolbag, feeling the schoolbag to be heavy and fatigue while carrying the schoolbag. Moreover, the combined effect of grade by gender and physical activity by gender were entered in the regression model as independent factors. The type of schoolbag and the method of carrying the schoolbag were not included in the model because most students used backpacks over both shoulders, making further analysis unnecessary. The level of significance was set at p<0 .05.

RESULTS

Out of the 732 students who completed the questionnaire, 614 students walked to school every day. There were 293 (47.7%) boys (age = 10.85 ±2.49, BMI = 20.17 ±3.58) and 321 (52.3%) girls (age = 10.96 ± 2.48, BMI =20.29 ± 4.12). Four hundred ten (66.7%) students of the sample participated in extracurricular physical activities.

Schoolbag use

The differences in schoolbag weight, type of schoolbag, mode of carrying and duration of walking with the schoolbag were not significant (p> 0.05) between boys and girls (Table 1). Chi-square analysis (x^2 = 6.538, p < 0.05) showed that more girls carried schoolbags weighing greater than 10% of their body weight than did boys.

Table 1. Schoolbag use characteristics for boys and girls.

Schoolbag characteristics	Boys	Girls	Total
		Mean (SD)	
Schoolbag weight (kg)	5.3 (1.3)	5.6 (1.3)	5.4 (1.3)
Duration of walking with the schoolbag (min)	9.22 (5.7)	10.25 (5.8)	9.7 (5.6)
		N (%)	
Schoolbag weight as % of BW			
≤10%	104 (35.1)	87 (27.1)	191 (31.1)
> 10%	189 (64.9)	234 (72.9)*	423 (68.9)
Type of schoolbag			
Backpack	281 (96.4)	301 (93.1)	582 (94.8)
Other type	12 (3.6)	20 (6.1)	32 (5.2)
Method of carrying schoolbag			
On both shoulders	275 (93.9)	283 (88.2)	558 (90.9)
Other method	18 (6.1)	38 (11.8)	56 (9.1)

* Statistically significant at $p<.05$

Of all the participants, 86.4% (530) of the students perceived their schoolbag as heavy. Of these, 52.3% reported that the schoolbag was consistently or frequently heavy (47.7% "sometimes", 33.2% "often", 19.1% "always"). Girls reported that their schoolbag felt heavy more frequently than boys (x^2 = 18.743, $p<$ 0.05). Furthermore, 72.9% (448) of the students reported that they felt fatigued due to carrying their schoolbag. Of these, 40.2% felt consistently or frequently fatigued (59.8% "sometimes", 24.7% "often", 15.5% "always"). Fatigue was reported more frequently by girls than by boys (x^2 = 10.821, $p<$ 0.001).

Pain site reports

Of the total sample, 64.2% of the students reported pain. In terms of the four body regions, 25.9% reported pain in their necks, 50.3% in their shoulders, 37.5% in their upper backs, and 20.8% in their lower backs. Girls experienced pain twice as often as boys (x^2 = 18.743, $p<0.05$). Students who reported pain spent more time carrying schoolbags compared to other students (t = -9.869, $p<0.05$).

The ANOVA showed a significant (F (2, 612) = 114.73, $p<0.001$, η^2 = 0.159) two-way interaction effect on physical activity (Table 2). Post-Hoc Tukey tests indicated that girls who felt pain participated in significantly fewer hours of physical activity per week compared to girls who did not experience pain ($p<$ 0.05). This observation was not applied for boys ($p>$ 0.05). In addition, the results showed a significant main effect (F (2,612) = 45.131, $p<0.001$, η^2 = 0.069) of gender on physical activity levels, in that girls were less active than boys.

The results for pain experienced in each body region are also reported in Table 2. For all regions, the gender by pain interaction effects were statistically significant ($p<0.05$), with η^2 values ranging from 0.14 to 0.66, indicating a large effect size for these significant interaction effects. Post-Hoc Tukey tests, indicated that girls who felt pain participated in significantly fewer hours of physical activity per week compared to girls who did not experience pain ($p<$ 0.05). Furthermore, boys who felt neck or shoulder pain did not display significant differences in hours of physical activity per week compared to those who did not experience pain ($p>0.05$).

Table 2. Hours of physical activity per week in boys and girls with (Pain) and without pain (No Pain) in each body region while walking with the schoolbag (* significantly different compared with children who reported pain).

	Boys		Girls	
Region	**Pain**	**No Pain**	**Pain**	**No Pain**
Any region	2.28 ± 1.04	3.11 ± 1.07	1.18 ± 0.68	4.77 ± 2.31*
Neck	2.75 ± 1.58	2.75 ± 1.72	1.29 ± 0.48	2.75 ± 1.51*
Shoulder	2.45 ± 1.16	3.12 ± 1.39	1.35 ± 0.83	3.47 ± 1.18*
Upper Back	2.41 ± 1.33	3.34 ± 1.21	1.32 ± 0.59	2.99 ± 1.43*
Lower Back	2.54 ± 1.52	3.74 ± 1.63*	1.37 ± 0.75	2.63 ± 1.73*

Table 3. Logistic regression of pain (all regions) occurrence when children carry their schoolbag.

Covariate	*p*	Odds Ratio (95 % C.I.)
Grade	0.406	0.848 (0.716-1.004)
Gender	0.392	0.548 (0.139-2.170)
Grade X Gender	0.038*	1.161 (0.974-1.384)
BMI	0.473	0.971 (0.897-1.052)
Schoolbag weight	0.968	0.995(0.793-1.250)
Relative Schoolbag weight	0.226	0.653 (0.328-1.301)
Duration of walking with the schoolbag	0.004*	0.934 (0.891-0.987)
Feeling the school bag to be heavy	0.117	0.461 (0.244-0.871)
Fatigue during school bag carriage	0.001*	2.455 (1.489-4.046)
Physical activity	0.001*	0.288 (0.210-0.396)
Physical activity X Gender	0.001*	3.170 (2.409-4.171)

* Statistically significant at $p<.05$

However, boys who reported upper back or lower back pain participated in significantly fewer hours of physical activity than boys who did not report pain ($p<0.05$).

The logistic regression showed that physical activity, grade by gender, physical activity by gender, fatigue experienced while schoolbag carrying, and duration of walking with the schoolbag, were significant ($p< 0.05$) predictors of pain occurrence (Table 3). However, data analysis revealed no significant association between pain and grade, gender, BMI or schoolbag weight ($p< 0.05$).

The results of the multinomial regression for region-specific pain occurrence are presented in Tables 4-7. The results showed that for all regions, there was a significant association between physical activity, physical activity by gender and fatigue experienced while carrying the schoolbag ($p<0.05$). Gender was a significant predictor for neck (Table 4), shoulder (Table 5) and lower back pain (Table 7), while the duration walking with the schoolbag was a significant predictor of shoulder (Table 5) and upper back (Table 6) pain ($p<0.05$). The model showed no association between pain and grade, BMI, or schoolbag weight.

DISCUSSION

The main findings of this study are that a) girls experience more frequent pain while carrying their schoolbags as compared to boys; b) the number of students who report pain increases at a higher rate after the 5th grade (10 years old) in girls than after the 5th grade in boys; c) girls with low physical activity levels are more likely to report pain incidents than more physically active girls; and d) students who carry the schoolbag for a longer period of time and those who feel tired when walking to school with their schoolbag are more likely to develop pain.

More than half of the students in our study reported pain while carrying schoolbags, which confirms the findings of several previous studies (9, 29, 31, 39, 43). Schoolbag use may be responsible for long-term effects on spinal curvature (kyphosis), spinal misalignment, and stiffness or spasm in the upper back and shoulder muscles (6, 21). However, although students felt pain while carrying schoolbags, the regression analysis showed that neither absolute nor relative schoolbag weight showed a significant association with pain (Tables 2-7). This is in

Table 4. Logistic regression of neck pain occurrence when children carry their schoolbag.

Covariate	*p*	Odds Ratio (95 % C.I.)
Grade	0.879	1.035 (0.663-1.616)
Gender	0.001*	0.061 (0.016-0.236)
Grade X Gender	0.004*	2.100 (1.261-3.497)
BMI	0.191	1.056 (0.973-1.146)
Schoolbag weight	0.701	0.950 (0.732-1.233)
Relative Schoolbag weight	0.333	1.054 (0.948-1.172)
Duration of walking with the schoolbag	0.180	1.025 (0.988-1.064)
Feeling the school bag to be heavy	0.084	0.474 (0.203-1.104)
Fatigue during school bag carriage	0.018*	0.512 (0.294-0.889)
Physical activity	0.001*	0.749 (0.656-0.856)
Physical activity X Gender	0.002*	1.303 (1.099-1.544)

* Statistically significant at $p<.05$

Table 5. Logistic regression of shoulder pain occurrence when children carry their schoolbag.

Covariate	*p*	Odds Ratio (95 % C.I.)
Grade	0.878	0.967 (0.625-1.494)
Gender	0.016*	0.276 (0.097-0.788)
Grade X Gender	0.745	0.933 (0.615-1.416)
BMI	0.601	0.979 (0.904-1.060)
Schoolbag weight	0.912	1.014 (0.793-1.297)
Relative Schoolbag weight	0.751	0.984 (0.891-1.087)
Duration of walking with the schoolbag	0.001*	1.075 (1.035-1.118)
Feeling the school bag to be heavy	0.009*	0.414 (0.217-0.802)
Fatigue during school bag carriage	0.002*	0.450 (0.285-0.711)
Physical activity	0.002*	0.658 (0.578-0.750)
Physical activity X Gender	0.002*	1.623 (1.387-1.899)

* Statistically significant at $p<.05$

agreement with some studies (10, 16-17, 21-22, 30-31, 34, 42) but contradicts the findings of others (11, 29, 37, 39-40). Our study, however, evaluated pain that occurs while carrying schoolbags, as opposed to back pain experienced during daily life activities, which is typically the focus of other studies. In any case, it is clear that schoolbag weight is not an independent contributor to back pain development in schoolchildren.

In contrast to schoolbag weight, the time spent carrying the schoolbag and fatigue were significant contributors to pain, which coincides with previous studies (7, 31, 39-40). The results of this study clearly suggest that schoolbag weight itself does not contribute to pain. Instead, it appears that schoolbag weight has an impact when the bag is carried for a long duration or when the student feels fatigued. The duration of carrying the schoolbag causes the trunk to lean forward and influences cervical and shoulder posture (6, 13, 15). Those postural changes could cause neck, shoulder, and back pain (6, 15) and alterations in posture (19). It should be mentioned, however, that this study could have drawn more definite conclusions about the role of schoolbag weight if pain had been assessed during all daily activities and compared with pain experienced while carrying schoolbags. Such comparison would allow a clear identification of the factors which affect general pain as distinguished from those which affect pain while carrying schoolbags. Despite this limitation, it is recommended that students reduce schoolbag weight and the daily duration of carrying their schoolbags.

The results of this study demonstrate that girls are more likely to report back pain when they carry their schoolbags. This is in agreement with certain previous studies on gender differences in general pain incidence (11, 22, 29-30, 34, 39, 42-43) and in disagreement with others (31). The regression models showed that gender, as a single factor, was a significant predictor of neck (Table 4), shoulder (Table 5) and lower back pain (Table 7) but not for general (Table 3) or upper back pain (Table 6). In contrast, grade showed no significant association with any type of pain (Tables 2-7). In addition, the grade by gender interaction contributed significantly to general pain (Table 3) and neck pain (Table 4). Since more girls reported pain as compared to boys, it is clear that gender differences in pain are gender and region-specific. This is better illustrated when the number of students who reported pain versus those who were pain-free is examined for each gender (Figure 2). It seems that until the 4th grade (9 years of age), there is an equal distribution of children who felt pain as opposed to those who did not feel pain. However, after 10 years of age, the number

Table 6. Logistic regression of upper back pain occurrence when children carry their schoolbag.

Covariate	*p*	Odds Ratio (95 % C.I.)
Grade	0.997	0.654 (0.654-1.532)
Gender	0.157	0.467 (0.163-1.340)
Grade X Gender	0.617	0.899 (0.593-1.363)
BMI	0.434	1.032 (0.954-1.117)
Schoolbag weight	0.411	1.109 (0.867-1.417)
Relative Schoolbag weight	0.510	1.034 (0.936-1.142)
Duration of walking with the schoolbag	0.003*	1.061 (0.263-1.007)
Feeling the school bag to be heavy	0.077	0.531 (0.264-0.700)
Fatigue during school bag carriage	0.001*	0.430 (0.636-0.817)
Physical activity	0.001*	0.720 (1.311-1.783)
Physical activity X Gender	0.001*	1.529 (0.853-1.196)

* Statistically significant at $p<.05$

Table 7. Logistic regression of lower back pain occurrence when children carry their schoolbag.

Covariate	*p*	Odds Ratio (95 % C.I.)
Grade	0.168	1.385 (0.872-2.199)
Gender	0.014*	0.198 (0.055-0.719)
Grade X Gender	0.728	1.090 (0.669-1.778)
BMI	0.564	0.975 (0.897-1.061)
Schoolbag weight	0.906	0.984 (0.751-1.289)
Relative Schoolbag weight	0.683	1.023 (0.918-1.140)
Duration of walking with the schoolbag	0.660	1.009 (0.971-1.048)
Feeling the school bag to be heavy	0.019*	0.329 (0.130-0.831)
Fatigue during school bag carriage	0.543	0.847 (0.496-1.446)
Physical activity	0.001*	0.780 (0.683-0.891)
Physical activity X Gender	0.001*	1.458 (1.233-1.724)

* Statistically significant at $p<.05$

of girls who consistently report pain increases. This is also observed for boys after 7th grade (12 years of age) (Figure 2). Grimmer et al. (11) also reported a higher increase in the number of girls who reported low back pain at higher grades than in boys at higher grades. In fact, in a previous study, Grimmer et al. (13) reported that peak height velocity shows a different relationship with changes in the cranio-vertebral angle among girls as compared to that measured in boys. This suggests that sexual maturation as well as differences in lifestyle and preferences regarding schoolbag use may be responsible for the observed gender differences in pain. Furthermore, it appears that the aforementioned grade by gender interaction affects neck pain and not pain in other body regions.

An important finding of this study was that physical activity showed a significant association with pain, irrespective of body region (Tables 3-7). This is in contrast to the findings of Jones et al. (17), who reported that neither the amount of physical activity at school nor the extent of sedentary activities had an effect on the future onset of low back pain in school children. This discrepancy may be related to differences in the method used to quantify physical activity, as we have measured the number of hours in systematic physical activities per week while Jones et al. (17) divided the sample into various categories based on the number of sport activities per week or the time spent on physical education at school per week. Furthermore, a key difference between our study and previous research is that we specifically examined pain that developed while walking to school and carrying a schoolbag, whereas other studies examined general body pain. Our observation might provide an explanation for the aforementioned significant association between fatigue and pain (Table 3). Schoolbag carriage may cause the trunk to lean forward lean when walking to school (15). However, this effect is not instantaneous but it is repeated each time the child walks to school or returns home. These results extend previous findings which indicate that low levels of physical activity are associated with more frequent and severe back pain in adolescents (14, 28, 36). Nevertheless, the relationship between low physical activity levels and back pain in children is not clear. In a review, Balague et al. (4) concluded that evidence on the association between muscle strength and non-specific low back pain in children is unclear. This is probably because muscle strength, measured under laboratory conditions, is only one component of physical activity and cannot be directly related to physical activity status, which is quantified using questionnaires (35). It is also noteworthy that excessive levels of physical activity are additional contributors to future low back pain (2, 4, 17). Consequently, although our results tentatively recommend the improvement of physical fitness levels as a strategy for pain reduction, excessive levels of physical fitness may also increase pain. It is possible that better physical fitness may be necessary to reduce pain and discomfort when children carry their bags to school, but excessive sport participation (for example, by elite young athletes) may increase musculoskeletal pain.

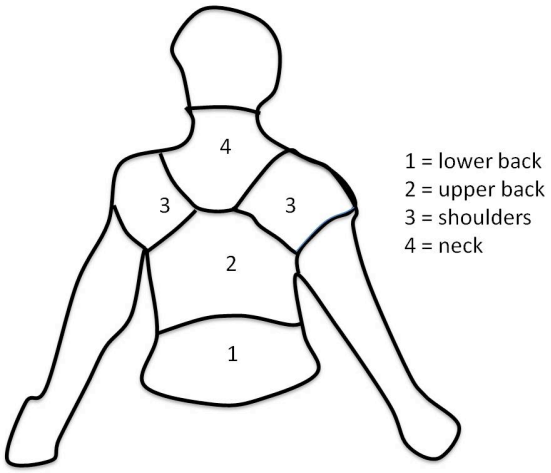

Figure 1: Pain regions evaluated while carrying schoolbags

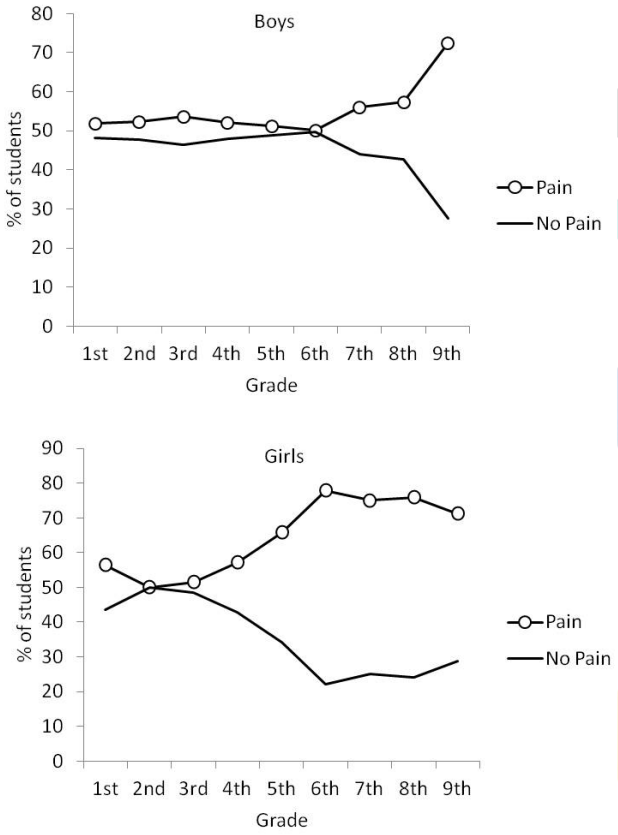

Figure 2. Percentage of students who reported pain and those who were pain free (while carrying the schoolbag), for each grade level.

The interaction between physical activity and gender was also a significant predictor of pain (Tables 3-7). This suggests that the negative effect of low physical activity levels on pain is more intense among girls than among boys (Figure 2). It seems that girls with low levels of physical activity have 3.14 times higher chances of developing pain than those who exercise more (Table 3). Of course, other factors, such as the different growth rates between boys and girls (39), should also be taken into consideration when examining back pain problems in children. Nevertheless, the present findings indicate that additional gender-specific interventions and physical activity programs within and outside school should be applied to reduce pain incidents.

In the present study, there was a significant association between pain and fatigue while carrying the schoolbags (Tables 3-7). Furthermore, feeling that the schoolbag was heavy was a significant predictor of shoulder (Table 5) and lower back (Table 7) pain. These findings are in agreement with Negrini and Carabalona (31) and Goodgold et al. (10), and they have been attributed to the high association between perception of fatigue and muscular fatigue (18).

A limitation of this study was that schoolbag weight was recorded only once. Consequently, the recorded data do not account for the variance of schoolbag weight during a typical week. Of the initial sample, 25% did not consent to participate in this study. Our experience from this project suggests that subject participation in screening studies is a difficult task. Even if the sample size was large, the percentage of students who refused to participate would be very similar. Given the cross-sectional nature of the present study, the long-term effects of schoolbag use on pain have not been delineated. Hence, longitudinal studies are deemed important to investigate whether students will continue to experience pain into their adult years. Future research should focus on whether students who experience pain while carrying a schoolbag also experience pain in their daily routines, and if these two pains are interrelated. Another factor which might also influence our results is the difference in sexual maturation between boys and girls. Unfortunately, our ethically approved protocol did not allow sexual maturation evaluation. Moreover, in our study, physical activity was measured using questionnaires. Although this may provide a sufficient view of a student's state of physical activity, quantitative measures may provide more precise information on physical activity and pain occurrence. Further research on gender by sexual maturation effects on pain in children is recommended.

CONCLUSIONS

Although previous research indicates that excessive levels of physical activity may increase back pain, our results suggest that very low levels of physical activity and fatigue resistance may also increase pain incidents due to carrying schoolbags. In general, girls were less physically active than boys, which may contribute to more pain and fatigue incidents reported by girls than by boys.

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