

# Influence of School Backpacks on Adolescent Back Pain

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**Summary:** In a sample of 3,498 students living in two counties in California, each student's weight and backpack load were measured. Demographic information as well as information about backpack use was obtained. Nonspecific mechanical back pain was found to be highly prevalent, and the reported severity and chronicity of pain were high. Controlling for age, socioeconomic status, walking to and from school, and method of wear, results indicated that backpack weight, measured as a percentage of body weight, was effective in predicting back pain ( $P < 0.01$ ). Girls and those who walk to and from school were more likely to report back pain ( $P < 0.01$ ). The method of wear, socioeconomic status, and age were not found to be significantly related to the prevalence of back pain. However, with regard to the severity of pain, older age ( $P < 0.01$ ), walking to and from school ( $P < 0.01$ ), and method of wear ( $P < 0.05$ ) were statistically significant.

**Key Words:** adolescent, back pain, backpack

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In the past, back pain in a child or adolescent was considered so infrequent that it warranted an extensive evaluation, under the assumption that the pain was secondary to a more serious condition.<sup>7,9,16</sup> Recently, however, reports have surfaced identifying an increasing number of schoolchildren with nonspecific back pain.<sup>1,2,17</sup> A recent literature review concluded that the lifetime prevalence of back pain in adolescents ranged from 30% to 51%, and medical attention was sought by approximately 4% to 31%.<sup>3</sup> Of equal concern is the rate of recurrent and chronic pain being reported by schoolchildren.<sup>11,13,17</sup>

Although the long-term consequences of back pain in schoolchildren are unknown, a Danish study supported future detrimental effects by reporting both a higher rate of hospital admissions and reduced functional capacity due to low back pain in adults who had had low back pain as adolescents.<sup>6</sup> Among the risk factors for the development of low back pain,

age has been universally regarded as a major influence on both the incidence and prevalence of nonspecific back pain,<sup>1,13</sup> implicating the time of peak growth as a substantial risk factor.<sup>2</sup> In addition, several of the cited studies also described a higher prevalence of low back pain among females.<sup>2,11,17</sup>

Of the factors linked with back pain in schoolchildren, none has stimulated greater parental anxiety and immediate attention than the use of school backpacks. With school lockers being removed due to vandalism and security concerns, schoolchildren are having to carry a significantly greater amount of weight in their backpacks, and for a much longer period of time: children have to carry a full day's class schedule of schoolbooks, in addition to other items and supplies, throughout the day. The sight of young children marching off to school heavily burdened by backpacks, coupled with a rising rate of nonspecific back pain among schoolchildren, has led to increasing parental and community unease.

In this study we sought to identify the significance of school backpack weight, recorded as a percentage of overall body weight, the method of wear, and the duration carried with socioeconomic status and the prevalence, severity, and chronicity of back pain affecting schoolchildren attending middle schools in the Inland Empire, a large region of Southern California.

## METHODS

### Study Group

Middle schools in Riverside and San Bernardino counties, two Southern California counties with large populations and vast geographic areas, were invited to participate in the study. Among the volunteer middle schools, four were selected based on socioeconomic status, two from San Bernardino County and two from Riverside County. Two of the four schools were considered of lower socioeconomic status, defined by a large amount of children participating in a free lunch program (Table 1). (Eligibility for participation in the lunch program is based on household size and annual income.) At one school 87% of the children participated in the free lunch program, and at the other 85% participated. The other two schools had 37% and 13% participation. Two of the schools used two sets of textbooks, with one set provided for home use, thus eliminating the need to carry books back and forth to school; however, this practice was not enforced. No school in

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**TABLE 1.** Summary of Schools

School	Sample Size	% Free Lunch Program	Socioeconomic Status
A	239	13%	High
B	961	85%	Low
C	740	37%	Moderate
D	557	87%	Low
<b>Total</b>	3,497	100%	

either district made lockers available for book storage (other than for temporary physical education purposes).

Seventh- and eighth-grade girls and boys participating in the study ranged from 11 to 15 years of age. This age group was selected due to the significant increase in the prevalence of back pain in this age group, supported by prior reports.<sup>1-3,11</sup>

### Data Collection

Seventh- and eighth-grade students were evaluated during gym class. One full school day for each school was required to assess all seventh- and eighth-graders attending school that day. The students were unaware of the day's events and thus were unlikely to make any changes in their routine backpack load. On the day of evaluation the students remained in their school clothes but were asked to remove their shoes, which researchers considered the heaviest and most variable and uncontrolled weight among their clothing items. The students were weighed and then their backpacks were weighed. The contents of the backpacks were not assessed. Measurements were made using two calibrated digital electronic scales, consistently accurate within 0.5 pounds. Body height was not measured or calculated into body weight (body mass index), as this had been found to be insignificant in prior reports.<sup>5,17</sup> We then calculated the ratio of weight of student to weight of backpack, in the belief that this would be an important factor in back pain.

### Questionnaire

Immediately prior to weighing, students completed a questionnaire comprised of 22 questions selected to identify the prevalence, chronicity, severity, and frequency of back pain. Age, gender, and grade were considered as potential crucial variables and were recorded as well.

The lifetime prevalence of back pain was identified by questions about whether the student had ever experienced back pain (Table 2). Back pain was identified as pain that originates in the neck/upper back and/or the lower back region. Chronicity and recurrence of pain were determined by questions focusing on the duration and frequency of pain experienced by the students who answered "yes" to the question above. Severity was assessed by questions asking whether the pain was bad,

very bad, or not bad. In addition, severity was assessed by questions asking whether school or gym class had been missed because of this pain and whether the student had visited a doctor due to the pain.

The influences of the method and duration of backpack use were assessed by whether the student used one or both shoulders or hands while carrying the backpack and if the backpack was carried to and from school.

Specific questions identified whether the students believed their backpack was a source of their nonspecific back pain, including whether they felt this pain while carrying their backpack and whether this pain improved once they removed the backpack. The students were also asked if they carried anything other than books in their backpacks.

## RESULTS

### Back Pain

Over 64% of the students reported having back pain at some time, 41.3% felt this pain when carrying their backpack, and almost all of them reported feeling relief upon taking off their backpack. Of those who reported back pain, 12.5% reported that their pain was "not bad," 87% reported that their pain was "bad" or "very bad," and 16.1% indicated that they had missed school, gym class, or after-school sports because of the pain. Further, 16.9% had been to a doctor for the back pain. Twenty-one of the students reporting back pain indicated their pain had persisted for over 6 months. In addition, 59% of the students noted recurring pain (23% monthly, 17% weekly, 19% daily). With regard to the use or weight of backpacks or the prevalence of back pain, no statistical difference was detected between the schools that provided two sets of books and the schools that did not.

### Demographic Factors

The ages of the students ranged from 11 to 15 years, with a mean of 13. The students were almost equally male and female. However, girls were much more likely than boys to report having back pain ( $P < 0.01$ ).

### Backpack Weight

The mean average backpack weighed 10.6 pounds (95% confidence interval, 10.41–10.71), with a range of 0.5 to 37.0 pounds. The ratio of backpack weight to student weight ranged from 0.30 to 43.42, with a median of 8.84. Bivariate analysis of the ratio variable and whether or not a student had pain showed that the larger the overall percentage of backpack weight to the weight of the student, the more likely the student was to report back pain.

### Walking to and From School

Forty-three percent of the students walked to and/or from school. Almost all children who walked to school walked

**TABLE 2.** Summary of Measures

	Percentages		Mean	Median
Gender	Male:	49.5%	—	—
	Female:	50.5%		
Socioeconomic status	Low:	43.4%	—	—
	Moderate:	21.2%		
	Upper:	35.4%		
Age	—		12.75	13.00
Weight of student to weight of backpack	—		9.33	8.84
Have you ever been to a doctor for this pain?	No:	83.1%	—	—
	Yes:	16.9%		
Do you walk to and from school?	No:	56.4%	—	—
	Yes:	43.6%		
How do you carry your backpack?	Both hands:	00.1%	—	—
	One hand:	01.9%		
	Both shoulders:	85.0%		
	One shoulder:	13.6%		
Ever feel pain in your back or neck?	No:	35.9%	—	—
	Yes:	64.1%		
How bad is this pain?	No bad:	12.5%	—	“Not bad”
	Bad:	75.3%		
	Very bad:	12.1%		
Have you missed school, classes, or sports?	No:	83.9%		
	Yes:	16.1%		
How long have you felt this pain?				
Less than 1 month	1 to 3 months	3 to 6 months	6 months to a year	
48.33%	1.82%	9.66%	21.58%	
N = 1,091	N = 461	N = 218	N = 487	
How often do you feel this pain?				
Once or twice	At least once a month	At least once a week	Once a day	
41%	23%	17%	19%	
N = 928	N = 531	N = 394	N = 421	

home from school. We observed a significant relationship between back pain and walking to and from school ( $P < 0.01$ ). However, the length of the walk, recorded from 5 to 30 minutes, was not statistically significant.

**Method of Wear**

Few students carried their backpacks in one hand ( $n = 63$ ; 1.9%) or in both hands ( $n = 18$ ; 0.1%). Most students wore their backpacks either on both shoulders ( $n = 2,868$ ; 85.0%) or over one shoulder ( $n = 424$ ; 13.6%). No significant relationship was found at the bivariate level between the method of wear and the prevalence of back pain.

**Multivariate Analysis**

For the multivariate analysis (Table 3), three key dependent variables were examined: “Have you ever felt pain in your

neck or back?” “Have you ever been to a doctor for your pain?” and “Have you ever missed school, gym, or sports because of your pain?” These three measures were used to assess the prevalence (model 1) and severity (models 2 and 3) of back pain among adolescents. The overall fit of model 1 was significant. Boys as well as those who walked to and from school were more likely to have back pain ( $P < 0.01$ ). Relative backpack weight (weight of backpack versus student weight) was associated with reported back pain in the bivariate analysis ( $P < 0.01$ ) (Table 4).

Figure 1 shows the predicted probabilities for boys and girls while varying the ratio variable (relative backpack weight) from its minimum (0.30) to maximum (43.42) value. This graph shows the effect of gender and the ratio variable on back pain while controlling for all other variables. The prob-

**TABLE 3.** Logistic Regression Analysis

Variables	Do you Feel Pain in Back?	Ever See a Doctor for Your Pain?	Have You Ever Missed Gym or Class Because of Your Pain?
	Model 1	Model 2	Model 3
Male	-0.471 (0.079)†	-0.236 (0.125)	-0.034 (0.127)
Moderate socioeconomic status	-0.092 (0.121)	0.029 (0.189)	-0.042 (0.199)
High socioeconomic status	0.093 (0.087)	-0.078 (0.135)	0.260 (0.138)
Ratio	0.039† (0.010)	-.007 (0.015)	-0.023 (0.016)
Age	-0.082 (0.059)	0.272* (0.094)	0.349† (0.095)
Walk to or home	0.327† (0.080)	0.091 (0.123)	0.454† (0.127)
Carry in one hand‡	-0.035 (0.639)	-0.382 (0.948)	-0.989 (0.815)
Carry over both shoulders	0.251 (0.570)	-0.525 (0.811)	-1.615* (0.692)
Carry over one shoulder	0.422 (0.581)	-0.345 (0.825)	-1.220 (0.706)
Intercept	1.141 (0.962)	-4.448* (1.466)	-4.709† (1.418)
-2LL	3780.4	1747.9	1679.7
LR X^2	84.48†	18.62*	49.11†
N	3005	1985	2011
Pseudo R^2	0.02	0.01	0.03

Standard errors are reported in parentheses.  
 Those who left questions unanswered were treated as missing data.  
 Significance: \* $P < 0.05$ , † $P < 0.01$ .  
 ‡The reference variable for this variable is “carry backpack in both hands.”

ability of back pain in girls ranged from approximately 0.37 to 0.75; for boys the range was approximately 0.20 to 0.63. Further, as the percentage of backpack weight increased beyond the observed maximum of 43.42, the likelihood of back pain approached 100% for both genders.

In model 2, we asked, “Have you ever been to a doctor for this pain?” The only significant predictor for this model was age: older students were more likely to see a doctor for their pain ( $P < 0.01$ ).

Controlling for all other variables in model 3, we observed that older students, those who walk to or from school, and those who carry their backpacks with both hands were more likely to have missed school or gym class because of their pain.

**DISCUSSION**

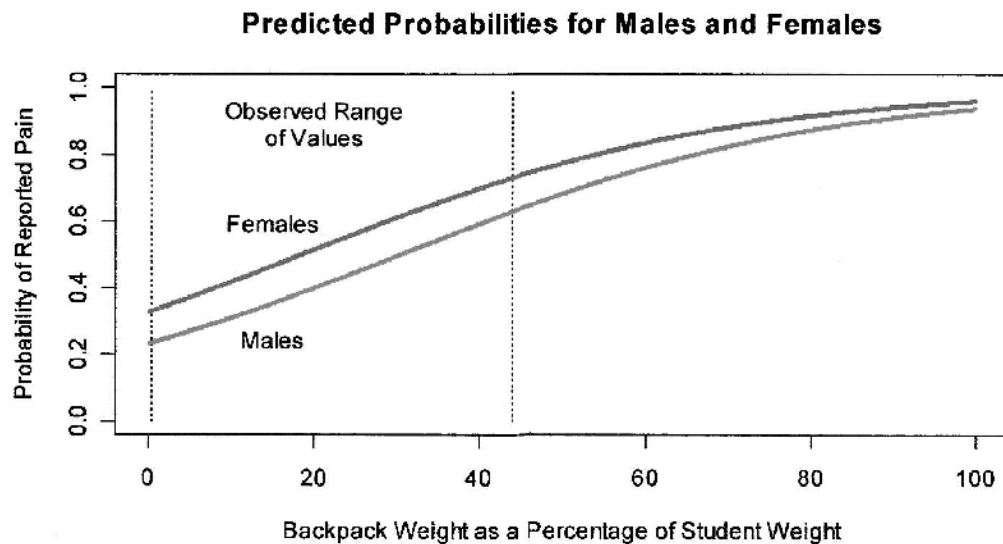
Several reports have noted detrimental biomechanical effects on normal posture with the use of school backpacks.<sup>4,10</sup> However, few articles have investigated the clinical consequences of the use of school backpacks in adolescents. Viry et al<sup>17</sup> studied the effects of school backpack weight on the presence of nonspecific low back pain in 123 eighth-graders in France. The children were asked to fill out a short questionnaire on a single day of school. Parents had previously been asked to weigh their child. Data collected included gender and the prevalence of back pain on the day of the study and during the past year, as well as severity, based on the need for physi-

cian visits and/or absence from school or sporting events. The duration of use and method by which the backpack was carried were also recorded. The mean backpack weight relative to the student’s body weight was 19.2%, and while increasing the relative backpack weight was associated with back pain, body mass index was not. The authors concluded that nonspecific adolescent back pain was associated with female gender and carrying a backpack weighing more than 20% of the student’s body weight. Both the prevalence of pain and pain severity requiring absence from school were associated with walking to school while carrying a backpack rather than traveling by vehicle. Carrying the backpack by hand rather than using the harness was associated with back pain severe enough to cause absence from school or sporting activities.

**TABLE 4.** Bivariate Analyses: Logistic Regression Results

	Pain in Back?	Ever See a Physician for Your Pain?	Have You Ever Missed Class or Gym for Your Pain?
Gender	0.61† (1.07)	0.81 (1.12)	1.02 (1.22)
Ratio	1.04† (1.01)	0.98 (1.03)	0.96* (1.01)
Walk to or home	1.34† (1.08)	1.21 (1.12)	1.53† (1.12)

Data are given as odds ratios, with standard errors reported in parentheses.  
 \* $P < 0.05$ , † $P < 0.01$ .



**FIGURE 1.** The probability of back pain increased as the weight of the load increased relative to the student's body weight. For boys, the probability of back pain was 0.27 with a backpack weighing 5% of body weight, 0.31 at 15%, and 0.40 at 20%. For girls, the corresponding probabilities were 0.37, 0.42, and 0.52.

Grimmer and Williams<sup>5</sup> surveyed 1,269 high-school students in Adelaide, South Australia, and recorded backpack load as a percentage of total body weight and height. Twelve state high schools were randomly selected, without consideration of socioeconomic or geographic factors, for this study, which was performed at each school within a duration of 1 week, measuring one class per day. The weights of students and backpacks were measured using the same calibrated digital electronic scale. The students were asked to complete a questionnaire reporting the presence of low back pain in the previous 2 weeks and time spent carrying the backpack, among others questions. Gender, age, the method by which the backpack was carried, and duration of use were also recorded. In regard to pain, only that of point prevalence was recorded; neither the severity nor chronicity of the pain was assessed. The authors found a strong association in all grades between low back pain and both backpack weight and the length of time carried. Again, girls were more likely to report low back pain than boys; girls' description of back pain increased in year 8, while boys reported a similar response 1 to 2 years later. The authors suggested that this finding may represent the relationship between the different peak growth phases between genders and the susceptibility of rapidly growing spines to back pain. While two thirds of the students preferred carrying their backpacks over both shoulders, there was no detectable association between low back pain and whether the two-strap or one-strap method of carrying was preferred. More than one fifth of the students were found to carry backpack loads greater than 10% of their body weight. While schoolbooks represented much of this load, personal equipment accounted for 10% to 20% of the total weight carried. Incorporating body height to

body weight (body mass index) did not create a statistically significant change.

Negrini and Carabona<sup>8</sup> recently performed a cross-sectional study of 237 sixth-graders in Milan, Italy. The children reported that their backpacks were heavy (79%), caused fatigue (65.7%), and caused back pain (46.1%). No significant difference between genders was detected. Backpack load was only indirectly associated with reported back pain by its relationship with fatigue while carrying a backpack and time spent carrying a backpack. The average load carried was 22% of the student's body weight. The method of wear was over both shoulders in 94.5%. The lifetime prevalence of pain, 47.7%, was associated with time spent carrying a backpack. In the three schools evaluated, statistical differences were found in the average backpack load carried between classes and between days of the week. The authors suggested that teachers' selection of daily work assignments affected the variable loads carried by students on a daily basis; manipulation of this, coupled with parent counseling, may reduce overall backpack loads. The authors also recommended conducting further studies in various geographic areas with different school systems.

To our knowledge, ours is the largest reported study of either the prevalence of nonspecific back pain in adolescents or its association with school backpacks. It is also the first reported study that we are aware of in the United States. The lifetime prevalence reported was an alarming 64%, with greater than 21% of schoolchildren describing chronic long-term pain of greater than 6 months' duration. Our results support prior reports indicating a high lifetime prevalence of nonspecific low back pain in adolescent schoolchildren.<sup>1-3,11</sup> Our report of a 59% rate of recurring back pain concurs with that

reported by Viry et al,<sup>17</sup> who reported a 57.7% rate of recurring low back pain among 14-year-old French schoolchildren. However, our rate of daily pain of 19% was considerably higher than their rate of 8.9%. The severity of pain was also quite significant, with 87% of the students reporting their pain as bad or very bad and approximately 16% of the students indicating that their pain was severe enough to require them to miss school or gym class or necessitate a visit to their doctor. The severity rate, as defined by missing school or requiring a visit to the doctor, of 16% among the adolescents in our study was approximately that found in prior studies<sup>3,17</sup> and is equal to that reported by Burton et al.<sup>1</sup>

We also found a statistically significant increase in nonspecific back pain affecting girls compared with boys. Although this conflicts with the results of Negrini and Carabalona<sup>8</sup> and Burton et al,<sup>1</sup> it corresponds with many prior studies.<sup>2,3,11,17</sup> This is consistent with the hypothesis<sup>8,15</sup> that these findings may result from a relationship between the susceptibility of rapidly maturing skeletal structures during the adolescent growth spurt and nonspecific back pain. During adolescence, differences in peak growth between boys and girls are noted, with growth peaking at approximately 12 to 13 years in girls and 2 years later in boys.<sup>14,15</sup> Thus, the mean age of the schoolchildren surveyed in this study (13 years) corresponds to the average age of peak growth in girls. This stage of susceptibility may be influenced by a load-induced environmental factor—hence the greater probability of reported back pain among girls per relative backpack weight noted in the current study.

Our results suggest that age does not have an effect in predicting back pain, which is inconsistent with many prior studies that indicate an increased prevalence of back pain with age.<sup>1,2,13</sup> However, our results do indicate that older students are more likely to see a doctor and are more likely to miss school or gym class because of severe pain. This, as with gender, implicates the time of peak growth as a substantial risk factor.<sup>2,17</sup>

Our results also confirm the high association between the use of backpacks and reported nonspecific low back pain in adolescent schoolchildren. Forty-one percent of the adolescents questioned indicated back or neck pain associated with the use of their backpacks, which is approximately that reported by Negrini and Carabalona,<sup>8</sup> and almost all of them felt relief from their pain after removing their backpack.

Our study confirms that the larger the percentage of backpack weight compared to the weight of the student, the more likely the student will be to report back pain. The average relative backpack weight reported of 10.6%, while less than that reported by Viry et al,<sup>17</sup> was consistent with that reported by Grimmer and Williams.<sup>5</sup> In the study by Viry et al, separate noncalibrated scales were used to weigh the student and the backpack: the parents weighed the student in an uncontrolled environment and the backpack was weighed using a medical

scale. Several researchers have suggested a specific percentage of body weight that, once surpassed, would indicate an increased likelihood of back pain,<sup>12,17</sup> while others have not found such a cutoff point.<sup>5</sup> Our study indicates that there is a gradually increasing prevalence of back pain as the weight of the backpack increases per the adolescent's body weight; thus, we cannot indicate a relative weight at which carrying a school backpack is unlikely to result in back pain. However, our results indicate that carrying a backpack weighing 5% of the adolescent's body weight is less likely to result in back pain than one weighing 20% of the student's weight (37% vs. 52% respectively). Thus, while we cannot recommend a "safety zone" with regard to relative backpack weight, our results support the belief that decreasing backpack weight correspondingly reduces the probability of back pain among adolescent schoolchildren.

In addition, our study concurs with prior studies that concluded that the duration for which the backpack is worn significantly influences the likelihood of back pain.<sup>5,8</sup> Our results also concur with those of Negrini and Carabalona<sup>8</sup> with regard to whether or not walking to and from school carrying a backpack is significantly related to back pain. Our results are highly consistent with those of Viry et al,<sup>17</sup> Negrini and Carabalona,<sup>8</sup> and Grimmer and Williams,<sup>5</sup> who found that among all the environmental factors they assessed, time spent carrying a backpack to or from school of more than 5 minutes was most consistently associated with back pain.

Surprisingly, the method of wear was not statistically significant in terms of the prevalence of back pain. These results were consistent with those of Grimmer and Williams<sup>5</sup> but not consistent with those of Pascoe et al.<sup>10</sup> We did note, however, that while the percentage of adolescents who carried their backpacks with both hands was small, this method was statistically associated with the presence of more severe pain, requiring the student to miss class or gym, which was identical to that reported by Viry et al.<sup>17</sup>

Controlling for other factors, socioeconomic status (low, moderate, or upper) did not appear to correlate with the prevalence of back pain or its association with the use of backpacks. The assumption was that students who have access to more resources may carry heavier backpacks and thus may be more likely to report back pain associated with backpack use. However, no statistical difference was detected between schools with regard to the use or weight of backpacks or the prevalence of back pain; thus, the variability of socioeconomic status among schools was not found to be statistically significant.

Of additional interest was the percentage of noneducational materials that students carried in their backpacks, which was found to be 30% in our study and 10% to 20% of the relative backpack load in the study by Grimmer and Williams.<sup>5</sup> Clearly the selection of items carried in the average student's backpack has an impact on the overall detrimental effects of backpack use.

Alternatives to the use of heavy backpacks have been suggested, such as rolling backpacks, lighter textbooks, use of lighter computerized educational resources, and even the return of lockers made of clear acrylic material to address safety issues. Eliminating excess noneducational items from the backpack load, a method supported in the current study, has also been suggested. The availability of two sets of books has been suggested and has been in use in several school systems. However, the current results indicate that if not enforced, this method is ineffective, with most students preferring to carry their texts back and forth to school. Another approach may be to limit the amount of time spent carrying the backpack, a major influence on both back pain prevalence and severity, by supplying a means of transportation such as carpooling.

The limitations of our study include that the fact that our survey did not investigate other sources of back pain, such as sports activity. Our survey was performed on 1 day and may not represent the average backpack load carried throughout the year. Also, to our knowledge, no method exists by which to detect individual psychosocial influences on the perception of load-induced nonspecific back pain, and therefore these influences could not be eliminated.

### CONCLUSIONS

This study involved a large cross-section of students attending four schools in two major counties in Southern California. The results reveal a disturbing prevalence of nonspecific back pain in adolescent children that conflicts with the notion that back pain in a young individual is uncommon and likely indicates a more specific etiology. Our results concur with prior studies indicating that girls are more likely to report back pain. Our results showed that older students are more likely to consult a physician or miss school or gym class due to their pain. This supports the hypothesis that the level of physical maturity may play a role in the reporting of back pain in adolescent individuals, with those undergoing periods of rapid growth more susceptible to nonspecific and possibly load-induced back pain.

The relative weight and duration of use of backpacks was also highly significant: students carrying heavier backpacks relative to their body weight were more likely to report back pain. The duration of use was strongly associated with both reported pain and severity.

These results indicate that nonspecific back pain affecting adolescent schoolchildren is becoming a major national, if not international, medical issue. The long-term effects of this nonspecific pain have not been assessed, but at least one study has indicated that adults who had nonspecific back pain as adolescents have more long-term disability and chronic pain experienced.<sup>6</sup> Studies are needed to find a way to alleviate these detrimental forces affecting adolescent schoolchildren, which clearly includes the use of school backpacks.

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