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Pediatric RESEARCH

POPULATION STUDY ARTICLE

Backpack weight and back pain reduction: effect of an intervention in adolescents

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BACKGROUND: To assess if an educational intervention is effective to reduce backpack weight and back pain in schoolchildren.
METHODS: We designed an intervention study in schoolchildren aged between 12 and 16 years aimed to reduce the weight of backpacks and back pain. The intervention was multifaceted, including an educational intervention with practical examples, advising on performing sports, postural habits, leaflets, stickers, and so on. The comparison group did not receive any intervention.
RESULTS: A total of 1668 schoolchildren took part in the study. We observed a high prevalence of carrying heavy backpacks, with 66–80% of schoolchildren carrying backpacks surpassing 10% of their body weight. Back pain prevalence was 30%. We observed that the intervention was significant in reducing the backpack weight in first-year schoolchildren but not in second-year. The intervention was also significant in reducing back pain in third-year schoolchildren but only in girls.
CONCLUSION: This study shows that an inexpensive intervention directed to reduce the backpack weight and back pain might have a positive effect in schoolchildren.

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INTRODUCTION

Back pain is a health problem that is on the rise among the adolescent population[1] and can restrict activities of daily living to an appreciable extent. Lifestyle, coupled with little sports activity, is thought to contribute to loss of muscle tone in the back (coupled with lack of training of abdominal/core muscles). In many cases, these problems begin in childhood,[2] when the adoption of inappropriate postures, both fixed[3] and prolonged,[4] is combined with the use of unergonomic school furniture whose measurements are not adapted to the anthropometric features of their users,[5–7] and with the daily transport of heavy loads, e.g., backpacks full of books.[8] Experts recommend that the maximum weight which schoolchildren carry on their backs should not exceed 10% of the body weight of children at an age when they are still growing and developing.[9] Furthermore, according to the 2011–2012 Spanish National Health Survey, 12% of schoolchildren aged 5–14 years and 35% aged 15–24 years are classified as sedentary. A total of 12% of teenagers and young adults aged 15–24 years have been medically diagnosed with chronic lower-back pain.[10]

Studies undertaken in various countries[11] have shown that an individual with back pain in adolescence is more prone to develop back disorders and injuries at adult age, and similarly, that excess weight in backpacks may cause osteomuscular problems of the neck, shoulder, and back, such as scoliosis.[12,13] This is more frequent in developed countries, where sedentarism and poor postural habits increase the incidence of back pain.[14] Moreover, lumbago ranks first among musculoskeletal disorders, since it generates a high use of healthcare services and is the second leading cause of medical consultation after diseases of the upper respiratory tract.[15]

An earlier study conducted by our group prior to the intervention reported in this paper showed a direct relationship between school bag weight and back pain, as well as a high prevalence of back pain among schoolchildren in general, and girls in particular.[16] As a continuation of this initial study, we designed an intervention targeted at reducing school bag weight and fostering habits that would reduce back pain in this population.

Accordingly, this study sought to assess the effectiveness of a corrective and preventive school-based intervention aimed at (a) reducing backpack weight in the 12- to 14-year age group; and, (b) reducing back pain in schoolchildren over the age of 14 years.

METHODS

Study scope

We carried out an intervention in the northern area of Lugo (Spain), which has a surface area of 1394 km^2 and ~75,000 inhabitants distributed across 15 municipalities, mostly rural. The study population comprised all schoolchildren undergoing first to third compulsory secondary education (CSE) (Educación Secundaria Obligatoria). In Spain, mandatory high-school education comprises four academic years (CSE1, CSE2, CSE3, and CSE4) covering ages 12–16 years. In this study, CSE4 students were not included. The study was conducted across the four academic years from 2004/2005 to 2007/2008, and covered the area's 11 state-run high schools, which have an average of 2000 registered schoolchildren per year. Because the study had voluntary participation, was anonymous, and there was no intervention at an individual level, it was not necessary to have the approval of an Ethics

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Committee. Nevertheless, the protocol was approved by the Hospital da Costa Ethics Committee in 2005. Once the directors of the schools accepted to take part in the study, parents were informed about the study. Children took part only if parents authorized participation.

Study phases

At the beginning of every school year, two visits were made to the participating schools. Head teachers were contacted beforehand to present the project and arrange dates in coordination with their respective Directors of Studies. On the first visit, all schoolchildren enrolled in CSE academic year 1–3 (CSE1, CSE2, and CSE3) were given a consent form, containing information about the study and confidentiality of data, as required by the ISO/IEC 27002 standard (Personal Data Protection Act/Ley Orgánica sobre la protección de datos de carácter personal 15/1999), along with a questionnaire to be completed by their parents or guardians. The questionnaire was designed ad hoc in order to answer the objectives of the study. The instrument was tested in a pilot study in participants to ascertain the comprehensiveness of the questions and the validity of the response categories. Those items conducting to unreliable replies were rewritten or removed until the questionnaire items were easily understood by potential participants. On the second visit, we collected the completed questionnaires, and in the case of schoolchildren having signed consent forms, took their anthropometric measurements (weight and height) and weighed their backpacks. At the date of the first visit, pupils were not advised of the date of the second visit, so as to avoid introducing any bias in backpack weight.

Intervention

On the initial visit of every academic year (between September and December), except for the first academic year (2004–2005), we conducted an intervention targeted at CSE1 and CSE2 schoolchildren. The intervention was the same across all schools and consisted of a 1-h presentation for each classroom. The projected slides showed good and bad postural habits, correct and incorrect backpack positions, advisable maximum weight loads, and the consequences of overloading, as well as the benefits and virtues of sports activities and good nutrition. The intervention was administered by a team of four nurses previously trained on the contents. After the presentation, there was a demonstration of stretching exercises, encouraging students to repeat the exercises there and also at home routinely. During the physical education lesson, these exercises were reminded by the teacher. Posters were placed in corridors and classrooms of CSE1 and CSE2 during all academic years. Posters were replaced yearly during the present research and therefore all schoolchildren from CSE1 to CSE3 could see the posters. Posters showed images of correct backpack positioning, postural hygiene, sports activities, and sets of stretching exercises. Following the talk, stickers and information leaflets were handed out to be shared at home.

Data collection

Questionnaire. A 10-item questionnaire was drawn up containing the following variables: age; sex; five dichotomous variables (yes/no): presence of injury or previously diagnosed back lesion (scoliosis, kyphosis, or other); absence or presence of back pain of more than 15 days' duration during the preceding year; whether a physician had been consulted in case of pain; improvement in pain during vacation periods; extracurricular activity; time devoted to sports and time devoted to sedentary activities (watching TV, laptop or video games, and studying) with categories: none, less than 1, between 1 and 2, and more than 2 h/day; transport used to travel to school (car, bus, and walking); and time spent carrying a backpack every day (less than half an hour, between 30 min and 1 h, and more than 1 h).

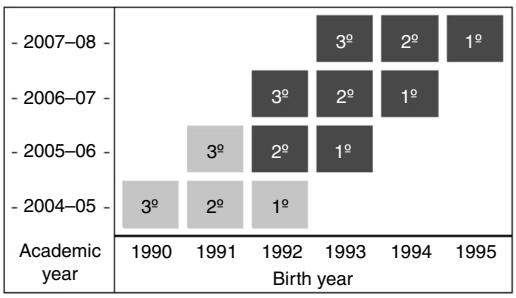

Fig. 1 Age–period cohort diagram to show control (gray) and intervention (dark) for each outcome. The X-axis represents birth year (cohort), Y-axis represents the school year, and the diagonal shows the academic year (age)

Measurements. Once the signed consent form had been collected, schoolchildren were weighed on a correctly calibrated, digital scale with a stadiometer attached (portable Tanita stadiometer to measure height (cm) to the nearest 1 cm; SECA Bellisima 841 scale to measure weight to the nearest 0.1 kg). Two weightings were performed, with subjects wearing no bulky outer clothing and stripped of all items that might add extra weight (keys, mobile telephones, etc.). The first weighing was performed with the backpack positioned correctly and loaded with the material that the subject was carrying to school that day. At the second weighing, schoolchildren were weighed with no load. When the data of the two weighings were compared, the difference was used to calculate the weight of the load (the reason for adopting this procedure was to prevent possible errors in backpack weight, resulting from poor or defective positioning on the scale), which was then related on a percentage basis to the subject's anthropometric measures. Height was recorded by having schoolchildren stand erect, with their backs to the stadiometer, the posterior aspect of their heads against the blackboard, and their heels together. In all cases, weight and height readings were taken by the same person.

Control and intervention groups

Impact of the intervention on backpack weight. The control group was made up of CSE1 and CSE2 schoolchildren drawn from the 2004/2005 academic year, and the intervention group was made up of CSE1 and CSE2 schoolchildren drawn from the three academic years from 2005/2006 to 2007/2008 (Fig. 1). CSE1 and CSE2 schoolchildren were analyzed separately because CSE1 schoolchildren during one academic year were mainly CSE2 schoolchildren during the next academic year.

Impact of the intervention on back pain. The control group was made up of CSE3 schoolchildren drawn from the 2004/2005 and 2005/2006 academic years, and the intervention group by CSE3 schoolchildren from the 2006/2007 academic year (who received the intervention when they were in CSE2) and the 2007/2008 academic year (who received the intervention when they were in first and second-CSE academic years) (Fig. 1). No specific intervention was given to CSE3 schoolchildren.

Statistical analysis

For each academic year, the characteristics of the control and intervention groups were described by reference to the distribution of frequencies. Using data on CSE1 and CSE2 schoolchildren, we calculated mean backpack weight, both absolute and relative to body weight and the percentage of schoolchildren carrying a backpack weight exceeding 10% of their body weight. Data on CSE3 schoolchildren were then used to calculate the percentage of schoolchildren with back pain, with stratification by sex due to the differences found between boys and girls. When analyzing the

Table 1. Characteristics of control and intervention groups of first and second grade of compulsory secondary education (CSE1–CSE2)

	CSE1					CSE2				
	Control		Intervention		*p*-value	Control		Intervention		*p*-value
	n	%	*n*	%		*N*	%	*N*	%	
Sex										
Boys	220	50.5	647	52.5	0.469	218	49.4	578	50.1	0.830
Girls	216	49.5	585	47.5		223	50.6	575	49.9	
Age										
12-years old	287	65.8	764	62.0	0.166	—	—	—	—	
13-years old	149	34.2	468	38.0		278	63.0	698	60.5	0.359
14-years old	—	—	—	—		163	37.0	455	39.5	
Body mass index categories										
Underweight	22	5.1	28	2.3	0.018	10	2.3	25	2.2	0.928
Average weight	255	58.5	691	56.1		266	60.3	678	58.8	
Overweight	114	26.2	369	30.0		121	27.4	324	28.1	
Obesity	45	10.3	144	11.7		44	10.0	126	10.9	
School bag										
Two shoulder straps	403	92.4	1179	95.7	0.008	405	91.8	1107	96.0	<0.001
Other type	33	7.6	53	4.3		36	7.9	46	4.0	
Back lesion										
No	349	92.8	827	91.1	0.377	339	92.1	764	91.3	0.629
Yes	27	7.2	81	8.9		29	7.9	73	8.7	
Walking to school										
No	285	75.8	692	76.2	0.886	270	73.4	614	73.4	0.996
Yes	91	24.2	216	23.8		98	26.6	223	26.6	

Table 2. Percentage of schoolchildren with backpack weight higher than 10% of their weight and 95% confidence interval, regarding schoolchildren characteristics

	CSE1			% (CI 95%)—CSE2		
	Control	Intervention	*p*-value	Control	Intervention	*p*-value
Overall	82.8 (79.3–86.3)	77.2 (74.9–79.5)	0.014	67.1 (62.7–71.5)	65.8 (63.1–68.6)	0.626
Sex						
Boys	81.4 (76.2–86.5)	75.1 (71.7–78.4)	0.057	61.5 (55.0–67.9)	62.3 (58.3–66.2)	0.832
Girls	84.3 (79.4–89.1)	79.5 (76.3–82.8)	0.131	72.7 (66.8–78.5)	69.4 (65.6–73.2)	0.367
Age						
12-years old	85.0 (80.9–89.2)	78.9 (76.0–81.8)	0.026	—	—	—
13-years old	78.5 (71.9–85.1)	74.4 (70.4–78.3)	0.304	70.5 (65.1–75.9)	69.3 (65.9–72.8)	0.721
14-years old	—	—	—	61.4 (53.9–68.8)	60.4 (55.9–64.9)	0.838
Overweight or obesity						
No	91.3 (88.0–94.7)	86.8 (84.3–89.3)	0.047	80.1 (75.4–84.8)	78.7 (75.6–81.7)	0.626
Yes	67.9 (60.7–75.2)	63.7 (59.6–67.9)	0.335	45.5 (37.9–53.1)	45.8 (41.2–50.4)	0.943
School bag						
Two shoulder straps	83.4 (79.7–87.0)	78.0 (75.6–80.3)	0.020	68.2 (63.6–72.7)	67.5 (64.7–70.2)	0.806
Other type	75.8 (61.1–90.4)	60.4 (47.2–73.6)	0.142	55.6 (39.3–71.8)	26.1 (13.4–38.8)	0.007

Comparison between control and intervention groups in the first and second grade of compulsory secondary education (CSE1–CSE2)

influence of body weight, we used the cutoff points proposed by Cole[17] to classify body mass index, which were transformed into two final categories (low or average weight and overweight or obesity).

For the indicators, "backpack weight exceeding 10% of body weight" (in CSE1 and CSE2) and "back pain in the preceding year" (in CSE3), prevalence odds ratios (PORs) were calculated using logistic regression models and adjusting for schoolchildren's characteristics.

Means, prevalences, and PORs are shown with their 95% confidence intervals (95% CIs), and between-group comparisons were performed with Pearson's χ^2 test in the case of categorical variables and the Mann–Whitney *U*-test in the case of continuous variables.

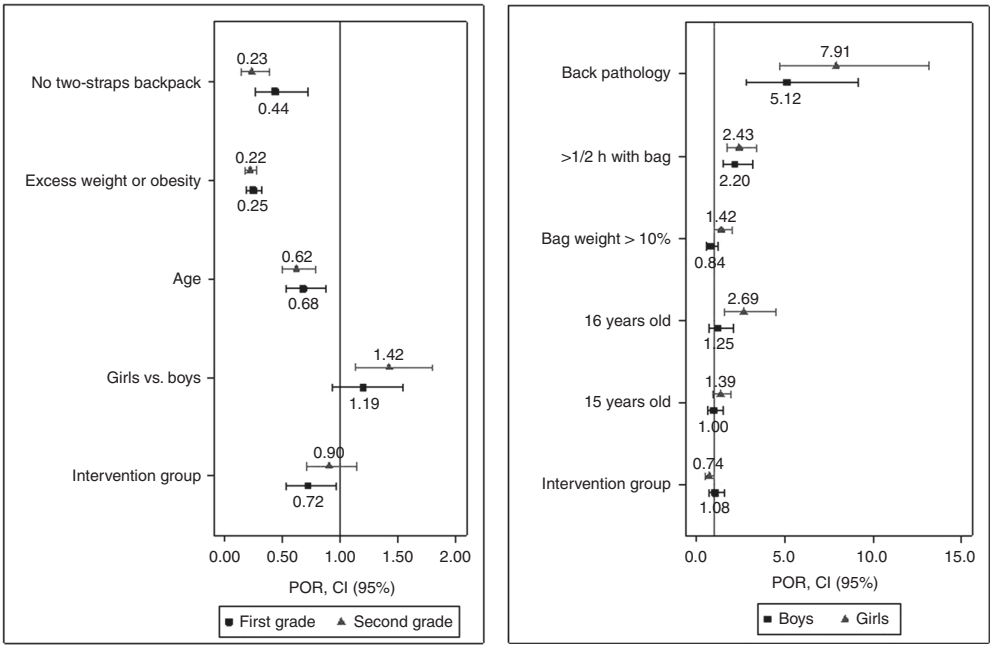

Fig. 2 Multivariate analysis results for the backpack weight in first and second years of CSE (left) and for back pain in the third year (right)

RESULTS

A total of 1668 CSE1 schoolchildren, 1594 CSE2 schoolchildren, and 1433 CSE3 schoolchildren participated in this study. Close to 80% of CSE1 schoolchildren and 66% of CSE2 schoolchildren carried a backpack with weights exceeding 10% of their body weight; among CSE3 schoolchildren, there was a 30% prevalence of back pain. A detailed flowchart of study participants is available as supplementary material of this paper (Supplemental Figure S1).

Effectiveness of the intervention to reduce backpack weight

CSE1. The intervention covered 1668 CSE1 schoolchildren aged 12–13 years, 436 in the control group (26%), and 1,232 in the intervention group (74%), with participation rates of 93% and 95%, respectively; 52% of participating schoolchildren were males, 63% were 12-years old, 40% presented overweight or obesity, and 95% used backpacks with two shoulder straps. Table 1 shows the characteristics of the control and intervention groups, which had a similar distribution by sex and age. In the intervention group, the prevalence of overweight or obesity was higher (36% vs. 42%), and there were more schoolchildren who used a standard (two-straps backpack) backpack (92% vs. 96%).

The mean weight carried by schoolchildren in their backpacks was 7.2 kg (95% CI: 7.1–7.3) and, on average, backpack weight accounted for 13.6% of body weight (95% CI: 13.4–13.8). The percentage of pupils who carried a backpack exceeding 10% of their body weight was 78.7% (95% CI: 76.7–80.6). Following the intervention, there was a significant reduction of 0.5 kg in mean backpack weight (95% CI: 0.3–0.7, $p < 0.001$), and 1.4% (95% CI: 0.9–1.8, $p < 0.001$) in mean weight relative to body weight. The percentage of schoolchildren with a backpack weight exceeding 10% of their body weight was 82.8% (95% CI: 79.3–86.3) in the control group, and 77.2% (95% CI: 74.9–79.5) in the intervention group. The intervention had a significant effect on boys, on children aged 12, on schoolchildren who had low or average weight, and those who carried backpacks with two shoulder straps (Table 2). The crude POR of the intervention vs. the control group was 0.70 (95% CI: 0.53–0.93; $p = 0.014$) and 0.72 (95% CI: 0.54–0.97; $p = 0.032$) when adjusted for sex, age, overweight or obesity, and type of backpack (Fig. 2).

CSE2. The intervention covered 1594 CSE2 schoolchildren aged 13–14 years, 441 in the control group (28%), and 1153 in the intervention group (72%), with participation rates of 98% and 96%, respectively; 50% of the schoolchildren participating were males, 61% were aged 13 years, 39% presented with overweight or obesity, and 95% used a standard backpack. Although the control and intervention groups had a similar distribution by sex, age, and body mass index (BMI) category (Table 1), in the intervention group, there were more schoolchildren who used a standard backpack (92% vs. 96%).

The mean backpack weight carried by schoolchildren was 6.9 kg (95% CI: 6.8–7.0) and, on average, backpack weight accounted for 11.9% of body weight (95% CI: 11.7–12.1). The percentage of schoolchildren who carried a backpack that weighed more than 10% of their body weight was 66.2% (95% CI: 63.9–68.5). Mean backpack weight, both absolute and relative to body weight, was slightly higher in the control group (7 vs. 6.8 kg and 12.1% vs. 11.9%) but the difference was not significant. The percentage of children carrying backpack loads exceeding 10% of their body weight was also higher in the control group [67.1% (95% CI: 62.7–71.5) vs. 65.8% (95% CI: 63.1–68.6)], without significant differences (Table 2). The crude POR of the intervention vs. the control group was 0.94 (95% CI: 0.75–1.19, $p = 0.626$), and 0.90 (95% CI: 0.71–1.14; $p = 0.390$) when adjusted for sex, age, overweight or obesity, and type of backpack (standard vs. other type) (Fig. 2).

Effectiveness of the intervention to reduce back pain

CSE3. The intervention covered 1433 CSE3 schoolchildren aged 14–16 years, 898 in the control group (63%), and 535 in the intervention group (37%), with participation rates of 73% and 54%, respectively. The control and intervention groups had a similar distribution by sex (48% and 47% of males, respectively), but differed in age, with 49% of the control group vs. 56% of the intervention group being 14 years of age. They also differed in other characteristics (Table 3). In the intervention group, a higher percentage used a standard backpack (96% vs. 90%), though 41% carried it for more than half an hour vs. 48% of the control group. The two groups had similar percentages of schoolchildren with back disorders.

Table 3. Characteristics of control and intervention groups in the third grade of compulsory secondary education (CSE3)

	Control		Intervention		*p*-value
	n	%	*n*	%	
Sex					
Boys	439	48.4	251	46.9	0.623
Girls	468	51.6	284	53.1	
Age					
14-years old	443	48.8	300	56.1	0.024
15-years old	330	36.4	173	32.3	
16-years old	134	14.8	62	11.6	
Overweight or obesity					
No	602	66.4	342	63.9	0.345
Yes	305	33.6	193	36.1	
School bag					
Two shoulder straps	819	90.3	514	96.1	< 0.001
Other type	88	9.7	21	3.9	
Backpack weight > 10% of the body weight					
No	414	45.6	243	45.5	1.000
Yes	493	54.4	291	54.5	
Time per day with the backpack on					
Less than half an hour	476	52.5	314	58.7	0.022
More than half an hour	431	47.5	221	41.3	
Walking to school					
No	605	66.7	387	72.3	0.029
Yes	302	33.3	148	27.7	
Performs sports regularly					
No	455	50.2	265	49.5	0.828
Yes	452	49.8	270	50.5	
Time per day watching TV					
Less than 1 h	322	35.5	229	42.8	0.018
Between 1 and 2 h	392	43.2	212	39.6	
More than 2 h	193	21.3	94	17.6	
Time per day on the laptop or video games					
None	413	45.5	186	34.8	< 0.001
Less than 1 h	276	30.4	177	33.1	
More than 1 h	218	24.0	172	32.2	
Time per day studying					
Less than 1 h	233	25.7	124	23.2	0.318
Between 1 and 2 h	312	34.4	204	38.1	
More than 2 h	362	39.9	207	38.7	
Back lesion					
No	802	88.4	483	90.3	0.274
Yes	105	11.4	52	9.7	

Table 4 shows the prevalence of back pain for boys and girls separately and for each group, with a breakdown by schoolchildren's characteristics. The percentage of boys with back pain was 23.5%, in both the control group (95% CI: 19.6–27.7) and the intervention group (95% CI: 18.4–29.3), and there were no observable differences between the two groups when these results were stratified by schoolchildren's characteristics. Among girls, in contrast, there was a higher prevalence of back pain in the control group (39% vs. 30%, $p = 0.018$), something that was also observed in girls aged 15 years, those who did not have overweight or obesity, those who had standard backpacks that were heavier, as well as other characteristics linked to physical activity (Table 4).

The crude POR of having back pain in the intervention vs. the control group was 1.0 (95% CI: 0.69–1.44) in boys, and 0.68 (95% CI: 0.49–0.93) in girls. On adjusting for age, the time spent carrying the backpack per day, suffering from a back lesion, and having a backpack weight in excess of 10% of body weight, values of 1.07 (95% CI: 0.73–1.57) were obtained for boys, and 0.74 (95% CI: 0.53–1.05; $p = 0.090$) for girls (Fig. 2).

DISCUSSION

These results show that an educational intervention targeting schoolchildren might reduce backpack weight, and that such interventions could also reduce the prevalence of back pain, though this latter outcome would seem to occur in girls rather than boys. Our results have to be considered with caution because this was not a randomized clinical trial and there is a risk of group contamination. Nevertheless, if this was the case, we should expect more relevant benefit than that observed. Another relevant result is that the percentage of schoolchildren who carry backpacks which exceed their body weight by more than 10% is very high, i.e., over 65%, and varies slightly with CSE academic year. Furthermore, the prevalence of back pain is also high, i.e., 30%. This is the study with the largest-sized sample to have been conducted on an educational intervention in schoolchildren to correct backpack weight.

The effect of the intervention on backpack weight proved to be statistically significant in CSE1 schoolchildren (average age 12 years) but not in CSE2 students. Among CSE1 schoolchildren, the prevalence of schoolchildren who carried a backpack that exceeded 10% of their body weight was reduced by just over 5%. Likewise, the intervention was more effective among boys than girls, though the effect on both sexes was very similar. Among CSE2 schoolchildren, the intervention was not observed to have any effect. These results send out two relevant messages: first, that there can be effective interventions to reduce schoolchildren's backpack weight; and second, that not all points in time are appropriate for such interventions. According to these results, schoolchildren are more receptive when they are in the CSE1 (age 12 years) than when they are in CSE2. The fact that the control group was composed of schoolchildren drawn from the schools at a time when the intervention had not yet been implemented, rules out contamination of the control group. Similarly, the fact that at any given school, there may have been intervention groups and a control group should not have affected the results. One possible explanation for the lack of results in CSE2 schoolchildren may be that their age renders them less receptive to messages focusing on certain aspects of their lifestyle than are CSE1 schoolchildren, who have only just commenced a new educational cycle. A study undertaken in Mallorca on fifth- and sixth-grade primary school schoolchildren (15–16-years old) has confirmed that the interventions undertaken at the school on habits related to backpack use are effective, and that their effects are maintained at 6 months of follow-up.[18]

Another very relevant aspect is that the intervention implemented proved extremely inexpensive, since it consisted of talks and the distribution of informative material by a trained nurse. It is likely that, if the intervention had been somewhat more intense, the benefit obtained might have been greater in respect of this variable. An intervention on backpack weight can be considered a "proxy" of back pain, since previous studies have shown an association between backpack weight and manifestation of back pain.[16]

In terms of the intervention's effect on back pain, a differential effect was in evidence for boys and girls: whereas no effect was seen in boys, a relevant and statistically significant reduction in the prevalence of back pain was observed in girls. This reduction in the prevalence of back pain was evident in the analysis of other

Tabla 4. Back pain prevalence in boys and girls in the third grade of compulsory secondary education (CSE3), regarding their characteristics

	% (95 CI%)—boys			% (95 CI%)—girls		
	Control	Intervention	*p*-value	Control	Intervention	*p*-value
Overall	23.5 (19.6–27.7)	23.5 (18.4–29.3)	0.990	38.7 (34.2–43.3)	29.9 (24.7–35.6)	0.015
Age						
14-years old	21.7 (16.2–28.1)	22.4 (15.6–30.4)	0.885	32.2 (26.4–38.5)	25.3 (18.9–32.6)	0.130
15-years old	22.0 (15.9–29.1)	23.8 (15.2–34.4)	0.740	44.0 (36.3–51.9)	30.3 (21.0–41.0)	0.033
16-years old	31.2 (21.1–42.7)	27.3 (13.3–45.5)	0.683	50.9 (37.3–64.4)	55.2 (35.7–73.6)	0.706
BMI categories						
Low weight/average weight	21.4 (16.7–26.8)	20.8 (14.5–28.4)	0.893	38.4 (33.1–43.8)	29.3 (23.1–36.2)	0.034
Overweight/obesity	26.8 (20.3–34.2)	27.1 (19.0–36.6)	0.954	39.4 (31.2–48.1)	31.4 (21.8–42.3)	0.225
School bag						
Two shoulder straps	23.6 (19.7–28.0)	23.5 (18.3–29.3)	0.963	38.4 (33.6–43.4)	30.0 (24.5–35.9)	0.026
Other types	18.8 (4.1–45.7)	25.0 (0.6–80.6)	0.780	40.3 (28.9–52.5)	29.4 (10.3–56.0)	0.407
Backpack weight > 10% of body weight						
No	24.7 (19.5–30.5)	24.5 (17.6–32.5)	0.958	33.7 (26.5–41.6)	29.8 (21.2–39.6)	0.502
Yes	21.8 (16.1–28.4)	22.5 (15.1–31.4)	0.886	41.3 (35.7–47.1)	30.0 (23.4–37.3)	0.013
Time per day with the backpack on						
Less than half an hour	17.6 (13.0–23.0)	15.6 (10.0–22.7)	0.620	28.7 (23.0–34.9)	23.7 (17.6–30.8)	0.258
More than half an hour	30.5 (24.2–37.4)	33.6 (24.9–43.3)	0.570	48.9 (42.3–55.6)	39.6 (30.5–49.4)	0.107
Walking to school						
No	24.1 (19.3–29.4)	20.0 (14.4–26.6)	0.303	37.1 (31.7–42.7)	28.5 (22.5–35.2)	0.043
Yes	22.2 (15.7–29.9)	32.4 (21.8–44.6)	0.108	41.8 (34.0–49.9)	33.8 (23.4–45.5)	0.238
Performs sports regularly						
No	28.4 (21.3–36.4)	23.4 (14.5–34.4)	0.421	35.8 (30.5–41.5)	27.7 (21.4–34.6)	0.060
Yes	21.0 (16.4–26.1)	23.6 (17.5–30.6)	0.512	44.1 (36.3–52.1)	34.4 (25.0–44.8)	0.124
Time per day watching TV						
Less than 1 h	28.1 (21.3–35.8)	23.3 (15.9–32.0)	0.365	45.1 (37.3–53.1)	33.6 (25.0–43.1)	0.057
More than 1 h	20.8 (16.2–26.0)	23.7 (16.8–31.8)	0.500	35.3 (29.9–40.9)	27.5 (21.0–34.8)	0.081
Time per day on the laptop or video games						
Less than 1 h	23.0 (18.5–28.1)	21.3 (15.2–28.4)	0.660	37.9 (33.0–43.1)	31.5 (25.2–38.4)	0.127
More than 1 h	24.6 (17.3–33.2)	27.5 (18.6–37.8)	0.634	41.7 (31.7–52.2)	25.9 (16.8–36.9)	0.028
Time per day studying						
Less than 2 h	23.8 (19.1–29.0)	20.9 (15.2–27.6)	0.471	38.0 (31.9–44.5)	27.8 (20.8–35.7)	0.038
More than 2 h	22.8 (16.0–30.8)	29.7 (19.7–41.5)	0.269	39.4 (33.0–46.1)	32.3 (24.5–41.0)	0.181
Back lesion						
No	20.1 (16.2–24.3)	20.9 (15.9–26.7)	0.788	31.8 (27.2–36.6)	24.9 (19.7–30.8)	0.061
Yes	57.5 (40.9–73.0)	58.8 (32.9–81.6)	0.926	81.5 (70.0–90.1)	65.7 (47.8–80.9)	0.077

Comparison between control and intervention groups

variables, e.g., there was a 14% reduction in prevalence among girls aged 15 years, which is a relevant figure from a clinical point of view.

In general, prevalence of back pain tends to be higher in girls than in boys.[19,20] A possible explanation for this higher prevalence of back pain in girls could be that bone structure is consolidated at a different age than it is in boys, or alternatively, that part of the reported pain might be attributable to menstrual pain. This study showed that, in terms of the percentage of schoolchildren who carry backpacks which exceed 10% of their body weight, this is far higher in girls than in boys (65% vs. 43%). Indeed, it is interesting to note that boys and girls carry approximately the same loads in their backpacks, with CSE3 boys and girls carrying backpack weights of 6.4 and 6.6 kg, respectively, yet boys weigh more than do girls (69 vs. 60 kg), so that the backpack-to-body weight ratio is actually higher in girls than in boys.

In addition to the intervention proposed in this study, a number of prevention activities to avoid excessive backpack weight were suggested.[21] On the one hand, parents of younger schoolchildren should be involved in organizing and supervising backpack contents.[22] It is not reasonable that older (and therefore more judicious) schoolchildren should be carrying lighter schoolbags than their younger counterparts. In fact, it is entirely feasible that, most of the time, younger schoolchildren tend to carry unnecessary material in their schoolbags. On the other hand, the use of backpacks with wheels in our sample was purely anecdotal: their use should be encouraged, to avoid heavy loads being carried for a long time. Finally, it would be necessary to inform parents and children of the basic aspects of postural education and the importance of not carrying excessive weight.[23] This task could be performed by nurses or educators directly at schools. Moreover, if this problem is to be remedied, the

involvement of teachers is crucial, e.g., one multifaceted trial found no effect in the intervention group when backpack weight was reduced, possibly due to a scant 17% teacher participation.[24] The arrival of new technologies may possibly replace books with weightless electronic devices, though this is not to be expected in the immediate future.

This study has a series of advantages, the most relevant of which was its design, i.e., its being a community intervention trial meant that it had a robust design for assessing the effectiveness of an intervention. Another advantage lay in the fact that no sampling was carried out: instead, the intervention included the entire sampling framework (universe) of schoolchildren who had agreed to participate and participation rate was high. This implies that there was no participation bias in the participants, and that the results are thus directly applicable to schoolchildren in the study area. We have not shown the results broken down by school because the area where the 11 included schools are settled has very similar characteristics, semiurban and coastal municipalities with no relevant cities. One last advantage linked to this was its large sample size, which implies that the results obtained are accurate, as can be seen from the confidence intervals of the different estimates.

Among the limitations of this study is one linked to its design, i.e., despite being an intervention study, it was undertaken sequentially rather than in parallel, and at any given school, there was a control group and an intervention group. There may be some risk of contamination of the control group, particularly from the placement of advertisements in the corridors of schools. Nevertheless, since the intervention comprised much more actions, we do not expect an important effect from this particular limitation. There is also some possibility of bias because some students might have modified the weight of the backpack after giving permission for participating in the study and before measuring backpack weight. We tried to minimize this without advertising the day the backpack was going to be measured. The intervention administered was not intensive (only at one point in time during the academic year). It will have to be seen whether interventions on, say, a quarterly basis, would have obtained a benefit of greater magnitude. Since the study was not designed from an ergonomic point of view, we do not have information regarding if students carrying standard backpacks (with two straps) used both straps or only one, or the height of the straps or even if the backpack had an additional strap to be fixed on the student's chest. The specific impact of these aspects on back pain should merit research in future studies. A final limitation is the variable, "presence of back pain", since this was self-reported and a subjective component in its assessment cannot therefore be ruled out, including the possibility of recall for long-time pain. In any event, researchers made every effort to ensure that this variable was reported in the same way in all participants.

In conclusion, this study has observed that reducing backpack weights by an average of 0.5 kg might be beneficial for schoolchildren. Moreover, this reduction and the intervention per se might have an influence on other trigger factors, by favoring activity, reducing sedentarism, and poor postural habits, whether in walking, sitting, or positioning the backpack correctly. The intervention itself was effective in reducing back pain, though only in girls. We cannot disregard the possibility of confounding despite having performed a multivariate logistic regression, so these results have to be managed carefully. The results obtained might have important socio-health implications, in that reducing back pain (with a high prevalence) in schoolchildren lessens their predisposition to suffer from lower-back disorders at adult age. It is also important to reduce the weight of backpacks and increase the use of backpacks with wheels when possible. The high prevalence of students (>65%) carrying backpacks exceeding 10% of their body weight shows that poor emphasis is given in preventing this risk factor for back pain and back pathologies.

AUTHOR CONTRIBUTIONS

All authors have contributed equally to the study design. Statistical analysis has been performed by MISP and MPR. Questionnaire supervision was performed by P.R.-O. and A.R.-R. All authors have provided intellectual input to different drafts of the present manuscript. All authors have approved the submitted version of the manuscript and take public responsibility of its content.

ADDITIONAL INFORMATION

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