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The backpack load in schoolchildren: clinical and social importance, and efficacy of a community-based educational intervention

A prospective controlled cohort study

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Aim. **The aims of this paper were: to establish the efficacy of an educational intervention in reducing school backpack weight and, possibly, back pain; to verify the content of backpacks and the social importance of the problem; to confirm existing data in the literature.**
Methods. **Design: controlled prospective educational intervention. Setting: community. Participants: the entire Year 6 population (402 pupils) of 2 randomly chosen rural school districts of the province of Mantua (Italy); of these, we took 108 (selected according to position in the class register): 82.4% completed the study; 402 parents and 124 teachers entered the study, 77.1% and 37.1% respectively completed it. Intervention: instructive meeting and written material for teachers, and a leaflet for parents on backpack management. Main outcome measures: backpack weight and content; back pain; subjective perceptions of backpack load; packing and carrying methods; backpack load: importance, management and education; backpack characteristics.**
Results. **We obtained a statistically significant reduction in the backpack weight in each of the groups (study 11.2%; control 7.9% - not a statistically significant difference); 90.1% of the material carried is necessary. Backpacks are considered a problem by 95.1% of parents, 73% of teachers, and 60.3% of pupils. Backpack weight: 8.75±1.26 kg (19.9±5.3% of body weight); fatigue during backpack carrying: 72.7%; back pain life prevalence: 58.4%; fatigue during backpack carrying and considering backpacks a problem were associated with back pain (odds ratios 4.4 and 5).**
Conclusion. **Educational intervention is not the answer to the problem and solutions, like the clear legal limits established for adults, need to be found.**

KEY WORDS: Child - School - Low back pain.

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Back pain (BP) in children has been increasingly recognized as a problem.[1-7] In the last few years many risk factors have been identified, but they did not include school bags [2, 6] until recently, when new data emerged.[8-10] Negrini *et al.*[10] found that the load carried daily by 11-year-old children is 9.3 kg, while the average weekly maximum load is 11.5 kg (ratio to body weight: 22% and 27.5%, respectively); 34.8% of pupils carry over 30% of their body weight at least once a week. The loads carried daily by children would not be allowed in adults as, proportionally, they exceed the legal limits established for workers,[10-12] but no limits have been established for application to the workplace of children (schools), and the limits generally proposed (10-15% of body weight) are widely exceeded every day.[10] Even taking into account the role played by psychosocial factors in both age groups,[1, 13] excessive loads can be associated with BP, both in youngsters,[2] and in adults.[14] While wearing their backpacks 46.1% of 11-year-olds com-

plain of BP, 79.1% find the backpack too heavy, and in 65.7% the backpack provokes fatigue; fatigue experienced while carrying a backpack is associated with BP (odds ratio 5.6).[8]

These results led Italy's highest health authority to adopt a stance on the issue in order to reduce the backpack load;[15] the Ministry of Education [16] and the Lombardy regional health authority [17, 18] were quick to respond, and the statements they issued prompted us to plan a preventive intervention at middle school level directed at all the parties responsible for determining the weight of backpacks (teachers, parents and pupils).[8] We thus designed a controlled prospective cohort study, whose aim was to establish the effectiveness of our multifactorial intervention in reducing school backpack weight, and to ascertain whether it could influence the BP reported by pupils. Further aims were to gather new data on the material carried in backpacks each day and on the way the problem is perceived by all the parties concerned, and to verify existing data on school backpack carrying.

Materials and methods

Participants

This study focused on the entire 1st year middle school population of 2 districts located in randomly chosen rural areas in the Italian province of Mantua. The districts were randomly allocated to the study group (SG) (Viadana: 9 classes, 201 pupils and parents, and 74 teachers) and the control group (CG) (Ostiglia: 9 classes, 201 pupils and parents, and 50 teachers).

A sample sub-group of pupils (54 per group) was recruited selecting 6 pupils from each class on the basis of their position in the class register. The average age was 11.2 years (range 10-12), weight 46.2 kg (30-76) and height 151.3 cm (137-168). There were no statistical differences between the 2 groups.

Evaluations and measurements

Only the pupils in the sample sub-group underwent the evaluations and measurements. Data were collected on: weight and height; weight of the material carried in backpacks categorized, following a discussion between the students of each class, as necessary (essential for the school day), additional (connected with the day's lessons) and superfluous; structural characteristics of the backpacks; way of carrying and filling the backpacks. A questionnaire, validated through piloting and a 2 week interval test/retest (29 subjects - proportion agreement: 78.9-96.3%; Spearman coefficient 0.69-0.82), was also used in the investigation: fatigue when carrying the backpack; how important the children consider the school backpack problem to be; the educational input of teachers and parents; daily use of the backpack; BP: prevalence, disability (absence from school), duration of pain, pain when carrying, lifting, or running with a backpack. These investigations were conducted at the start of the morning, before the backpacks were opened, on 2 days of the week, not known in advance by the teachers and pupils. The evaluations and measurements were repeated after the intervention, on the same days of the week. We analyzed the data of the 47 pupils in the SG and 42 in the CG who were at school on the 4 days when the evaluations were performed.

The parents and teachers were administered 2 questionnaires, validated through piloting and a 2 week interval test/retest (29 subjects - proportion agreement: 75.9-100%; Spearman coefficient 0.37-0.87), in which they were asked to indicate: how important they consider the school backpack problem to be; exchanges they have had on this issue with their children/pupils, and with other parents/teachers; how often they find unnecessary material in their child's/pupil's backpack. Anonymity was guaranteed in accordance with current Italian law. In the SG, 66.1% of parents and 24.2% of teachers answered the questionnaire as opposed to 88.1% and 56% in the CG.

Intervention

The intervention targeted solely the SG. The study was approved by the local health and education authorities. Rehabilitation specialist doctors were called upon to lead the instructive meetings for teachers, in collaboration with the heads of the schools involved. These meetings dealt with the following topics: scientific and legislative background; correct way of filling and carrying a backpack; first results of the evaluations carried out. Teachers were also urged to discuss the problem with their pupils. Only 17.3% of the teachers attended the meeting. The written information was also sent to teachers not attending the meeting.

An instructional leaflet was produced for the families in order to raise their awareness of points to con-

TABLE I.—*Comparison of replies to the questionnaires given by students, teachers and parents.*

	Students (%)	Teachers (%)	Parents (%)
How important is the problem?			
Very	8.5	5.8	42.7
Quite	51.8	67.2	52.4
Not very	29	21.2	3.6
Not at all	10.7	5.8	1.3
	χ^2=179.167 (p<0.001)		
Do you speak of the problem with			
Your pupil/children?		88.2	93.2
Teachers?	78.1	81.6	42.8
Parents?	77.4	71.9	79.3
How often is superfluous material present?			
Always	0.9	20.7	2
Often	3.4	60.4	4.9
Sometimes	52.7	18.9	46.1
Never	43.1	0.0	46.7
	χ^2=281.011 (p<0.001)		

sider when purchasing a backpack, of the correct way of filling and carrying it, and of the importance of encouraging motor activity in youngsters. These leaflets were accompanied by a letter from the head of the local health authority.

It was assumed that the pupils in the SG would be reached indirectly through discussions with their teachers and parents. Furthermore, backpack weighing and discussion of weights carried constituted a direct intervention that involved all the children in both groups.

Statistical analysis

We applied the following procedures: proportion of agreement and Spearman rank coefficient; Student's *t*-test for paired/non paired data and his nonparametric corresponding Wilcoxon and Mann-Whitney, normality of data was assessed with Shapiro-Wilks W test; McNemar and z-test for proportion. The level of significance was set at 0.05. Software used: Excel 5.0, Statgraphics 3.0.

Results

School backpacks are considered a problem by all those involved in school life (Table I). The average daily weight of backpacks was found to be 8.75±1.26 kg corresponding to 19.9±5.3% of body weight (Table II); on the 2 days considered, 11.2% of the subjects transported loads the equivalent of as much as 30% of their own weight; 90.1% of the total backpack weight is made up of necessary material (Table II); 95.8% of students (and 93.1% of parents) maintain that they (or their children) only sometimes or never take unnecessary material to school; on the contrary, 81.1% of teachers claim this to be often or always the case

TABLE II.—*Backpack weights (in kg) recorded in the 2 groups.*

	Total Av (range)	Study group		Control group	
		Pre	Post	Pre	Post
Backpack weight	8.75 (5.75-11.65)	8.93 p<0.05	7.93	8.56 p<0.05	7.88
% body weight	19.9 (10-34)	20.9 p<0.05	18.5	18.5 p<0.05	17
Necessary weight	7.8 (4.3-10.88)	7.98 p<0.05	7.49	7.78 <0.05	7.23
Additional weight	0.46 (0-3.03)	0.45 p<0.05	0.16	0.47 p<0.05	0.15
Superfluous weight	0.41 (0-2.7)	0.49 p<0.05	0.27	0.31 p=NS	0.51*
Necessary weight: % of total	90.1 (69-100)	89.5 p<0.05	94.5	90.9 p=NS	91.9
Additional weight: % of total	5.3 (0-31)	5.1 p<0.05	2	5.5 p<0.05	1.9
Superfluous weight: % of total	4.6 (0-28)	5.5 p<0.05	3.3	3.6 p=NS	6.2*

NS: difference not statistically significant. *) Statistically significant difference between pre/post evaluation in each group. Av: average *t*-test for paired data/wilcoxon test.

TABLE III.—*Effect of the intervention on low back pain. The duration of the episode values take into account episodes lasting longer than 1 day.*

	Total	Study group		Control group	
		Pre	Post	Pre	Post
Lifetime prevalence of back pain (%)	58.4	52.8	60.4 p=NS	63.5	58.8 p=NS
Prevalence of back pain the past 3 months (%)	41.9	39.6	44.2 p=NS	44.2	38.8 p=NS
Disability due to back pain in the past 3 months (absence from school) (%)	0.95	0	0 p=NS	1.9	2.1 p=NS
Duration of the longest episode of back pain in the past 3 months (days)	3.9	2.6	12.8 p=NS	5.1	13.9 p=NS
Frequent fatigue when carrying backpack	72.7	77.4	58.5 p=NS	70.6	67.3 p=NS
Backpack considered a frequent problem	57.3	54.7	45.3 p=NS	67.3	46.1 p=NS
Frequent low back pain when carrying backpack	46.8	47.8	57.9 p=NS	45.4	61.3 p=NS
Frequent low back pain when lifting backpack	53.13	54.5	53.7 p=NS	51.4	46.9 p=NS
Frequent low back pain when runing with backpack	32.9	33.3	54.8 p=NS	32.4	42.9 p=NS

Pre: before the intervention. Post: after the intervention. NS: difference not statistically significant. McNemar test and x-test for proportion.

(Table I). Nearly all the backpacks were found to have padded shoulder straps (98.9%), hard backs (97.7%) and concertina zips (94.1%), while only very few had waist belts (6.9%). Although concertina zips were usually left open (85.37%), the material inside was closely packed (70.37%); adherence of the backpack to the subject's own back was guaranteed in only 47.19% of cases; practically all the youngsters (94.2%) carry their backpacks on both shoulders.

BP had been experienced more than once during their lifetime by 58.4% of the pupils and 88.5% of them reported pain during backpack-related activities (lifting, carrying, running with the backpack on their shoulders), (Table III); 57.3% of the pupils considered their backpack to be a problem, while in 72.7% backpack carrying provoked fatigue (Table III). Fatigue experienced while carrying a backpack and consider-ing the backpack to be a problem was associated with BP [OR (95% CI): 4.4 (1.6-12) and 5.0 (2-12.5)]; BP was not associated with the backpack weight, *per se* or body weight-related, nor was it related to time taken getting to school (Table IV). No statistically significant differences emerged between the 2 groups studied in any of these parameters.

Postintervention modifications

The 2nd weighting sessions revealed a statistically significant reduction in backpack weight in both the groups, with a 2.1% drop in the backpack to body weight ratio; a significant reduction in superfluous weight was seen in the SG, as opposed to an increase in the CG (statistically significant difference): these reductions were in the order of hundreds of grams (Table II). The intervention was not found to influence: the prevalence of BP, the sensations during backpack carrying (Table III), the way backpacks are filled, or the educational approach of adults (Table V).

TABLE IV.—*Associations between back pain and perceptions associated with backpack carrying.*

		Prevalence in the past 3 months		Lifetime prevalence		Backpack related pain	
		Pain	Idle	Pain	Idle	Pain	Idle
Fatigue during backpack carrying	Yes	33	31	44	20	51	5
	No	5	19	8	16	12	8
		p<0.05		p<0.05		p<0.05	
Backpack considered a problem	Yes	28	23	38	13	40	6
	No	10	28	14	24	23	8
		p<0.05		p<0.05		p=NS	
Backpack weight/body weight ratio	<20%	25	25	29	21	33	9
	≥20%	13	26	23	16	30	5
		p=NS		p=NS		p=NS	
Time spent bearing the backpack on the shoulders	<15 min	15	20	20	15	25	4
	≥15 min	23	31	32	22	38	10
		p=NS		p=NS		p=NS	

NS: difference not statistically significant.

TABLE V.—*Children's reports of educational input from adults.*

	Study group		Control group	
	Pre (%)	Post (%)	Pre (%)	Post (%)
Parents	71.7	77.4	76.5	90.4
	p=NS		p<0.05	
Teachers	79.3	66.2	68.6	78.4
	p=NS		p=NS	

Pre: before the intervention. Post: after the intervention. NS: difference not statistically significant McNemar test.

Discussion and conclusions

Our backpack data are comparable to those obtained previously in a metropolitan population (the present study focuses on a prevalently rural population), again Italian.[10] Youngsters regard the contents of their backpacks as material that they actually need; even the additional and superfluous weights were generated almost exclusively by didactic material. The percentage of unnecessary material carried to school is judged entirely differently depending on who is asked: it could be that teachers are more likely to appreciate what material present in the children's backpacks is superfluous, or that children take to school unnecessary didactic material because they do not have a clear idea of what they genuinely need. Careful instructions from teachers could be a first step towards solving the backpack weight problem.

The daily backpack load is regarded as a problem by all the parties involved, although pupils and teachers are the groups that are less concerned: it is possible that parents tend to be overprotective, or that pupils and teachers implicitly apply a different scale of values to school matters, considering other elements to take precedence over physical health. In fact, in answer to direct questions on the sensations produced by carrying a backpack, children readily report discomfort.

All the backpacks were found to be correctly equipped with padded shoulder straps and hard backs, but the strap adjustment buckles tended to give once the full backpack was on the child's shoulders, and the hard backs are frequently bent, causing a shifting of the load away from the back. Paradoxically, it appears that school backpacks are not designed to withstand the impact of such large weights. Concertina zips, that increase the amount of material that can be carried and allow an extension of the load in the horizontal plane, are almost always present. Very few backpacks are fitted with waist belts, that help to keep the backpack flush with the spine and to transfer part of the weight on to the hips.

BP is common in this population: the life prevalence is higher than that reported in the literature,[1-3, 5, 6] although comparable to that recently found in Italy.[4] The subjective perception of the load, and the association between BP and fatigue, confirm some of the results previously obtained;[8] it was not possible to prove an association with the time taken getting to school, while previously the time subjects spend carrying the backpack themselves was found to be associated with BP:[8] the way questions are phrased seems to influence the final results. Nevertheless, backpack weight, *per se* or body weight related, was once again shown not to be associated with BP.[2, 6, 8] The question of whether BP is due to the physical act of carrying a load or to the psychosocial conse-quence of discomfort [8] remains to be clarified, although the perception of fatigue in the back proved to be highly correlated with muscular fatigue.[19]

Postintervention modifications

The absence of a significant difference between the 2 groups suggests that the intervention was not effective. Different factors may have contributed to this result, like the low rate of teacher participation: only 17% attended the instructional meeting; their involvement, fundamental for any educational intervention conducted at school level, is a critical problem that must be addressed. However, we found a statistically significant reduction of backpack weights in both groups. The weighting session and the discussion that took place in order to define the different weight categories may have made pupils in both groups more aware of the need to pay attention to what they take to school. Moreover, our intervention coincided with an unanticipated distribution by the regional government of Lombardy of posters and leaflets on the topic. Finally, the markedly higher rate of responses to the questionnaires found in the CG suggests that this group was more sensitive to the issue even prior to the start of the study.

The only important differences that emerged concerned superfluous weight, and the proportion of necessary weight in the backpack. Having specific aims, the intervention produced changes in certain

specific parameters: however, the relative extent of these changes (the unnecessary material accounts for around 10% of the total) was not sufficient to produce a perceptible alteration in the overall backpack weight.

The intervention did not alter the prevalence of BP or the sensations during backpack carrying: the very limited reduction in backpack weight, the question of whether intervention on just one possible risk factor can affect the final result and the unknown time that must elapse before a change is possible, may explain these results.

It must be noticed that there was a non-statistically significant increase in considering the backpack to be problem in the SG, whose data almost reached the higher basal levels present in the CG. This phenomenon might be due to an increased awareness of the problem produced by the intervention: such explanations have already been widely proposed in adult populations [13, 14] and also in children.[1]

The intervention was not found to alter significantly the way backpacks were filled, even though the results obtained (zips normally left open, but material nevertheless arranged in a compact manner) are practically inevitable, given the vast quantity of things youngsters carry in their backpacks. Despite the absence of a specific intervention, the parents of the CG were found to discuss the backpack problem at greater length with their children: this may have been the result of parents themselves taking on the responsibility for the follow up, as this group was not targeted by a specific intervention (the supply of information on the topic) after the filling in of the questionnaire, and the backpack weighing sessions required by the study.

In conclusion, according to these results and previous studies,[8, 10] in the light of its social importance, of the fact that it proportionally exceeds loads permitted in adults,[10] of the hypothesis that it could be a risk factor for BP8 to which all the population is systematically exposed, and of the discomfort it clearly causes our children,[8] the daily load of the school backpack cannot continue to be ignored by the scientific, political and educational community. The intervention conducted by us produced poor results: solutions to the school backpack problem need to be found that, like the clear legal limits in adults,[11, 12] go beyond mere education. Educational interventions are worthwhile, but are not the answer. In the meanwhile, the scientific community should produce more precise data on which to base the weight limits to be proposed, and verify more clearly the possible associations with spinal pathologies.

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