No kidding: low back pain and type of container influence adolescents' perception of load heaviness

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Abstract

Purpose The relationship between low back pain (LBP) and the lifting/carrying of loads is still a matter of great discussion. In teenagers, the weight of the school bag has been considered to play a pathogenic role in LBP but the relationship between the actual weight of the school bag and LBP symptoms does not seem to be a straightforward one. Numerous factors have been identified that influence the perception of weight. This study aimed to evaluate the influence of low back pain and the type of container on the perception of load heaviness by healthy teenagers.

Methods A convenience sample of 80 healthy teenage males (mean $\pm$ SD age 13.9 ± 2.1 years) was recruited from the members of two local sports clubs. The volunteers were evaluated during one of their training sessions. Information about a history of consequential LBP was gathered by questionnaire. Subjects were invited to estimate the weight of three bags (a typical school bag, a sports bag with the logo of a well-known brand, and a neutral

bag) containing two different loads (total weights approximately 3 and 5 kg).

Results Consequential LBP (i.e., LBP requiring medical attention and/or interfering with usual sports activities) was reported by 26.2 % of them. The majority of the LBP episodes occurred ≥ 3 months before the tests. Overall, teenagers significantly ($p \leq 0.05$) underestimated the weight of the sports bag compared with the school bag and the neutral bag. Compared with those with no LBP, subjects with a history of LBP overestimated the weight of the heavier load.

Conclusions Our results suggest that several subjective variables significantly influence the perception of load heaviness. Until we have a better understanding of the mechanical role of the backpack weight versus the perception of its weight in the aetiology of LBP, any recommendations about the schoolbag weight limit should be viewed with caution.

Keywords Adolescents · Low back pain (LBP) · Sport · School bag · Load

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Introduction

The frequency and burden of low back pain (LBP) are well known [1, 2]. In western countries, it is commonly assumed that the lifting and carrying of loads are associated with low back pain (LBP) and, as such, regulations exist regarding the maximum acceptable loads that can be manually handled by workers [3]. However, the relationship between LBP and spine load and tolerance is complex, with loading being influenced by both the physical environment and mental demands [4]. In relation to juvenile LBP, a much-discussed and frequently criticised load is the

schoolbag. An elegant study by Negrini and Carabalona [5] revealed differences of up to 100 % in the actual backpack weight (range 4.2–9.5 kg) of children in the same class, on the same day of the week (implying an identical school program on the day of the survey). A recent review has highlighted the conflicting information reported in the literature in relation to the recommended maximum load limits for schoolchildren, with values varying from 5 to 20 % of body weight [6]. Overall, the evidence linking backpack weight to back pain appears inconclusive [6], and the relationship between LBP and schoolbag carrying is far from straightforward. Some studies have shown that there is a statistically significant association between LBP and the perceived heaviness of the backpack (but not its actual weight) [5], whereas others have found no such association [7]. It has also been reported that, in addition to the perceived weight of the school satchel, socio-economic and demographic characteristics, such as school district, female gender and school grade, may contribute to backpack-related pain [8].

There is a long history to the scientific interest in the perception of load heaviness. Findings such as the “size–weight illusion” (objects of identical weight but of different shape and density differ in apparent heaviness, with the smaller looking heavier), “time-order error” (if two objects of identical weight are evaluated successively, the second one feels heavier), and the “space error” (a given weight is usually perceived heavier in the left hand than in the right hand) were published in the second half of the XIXth century [9]. Some authors distinguish the material–weight illusion from the size–weight illusion, where varying the material properties of an object, rather than its size, modifies one’s perception of its weight [10].

Since these phenomena were first identified, the volume of the literature on the perception of load heaviness has increased exponentially. As an example of the complexity of weight perception, it has recently been shown that even when the force of gravity is by-passed, the size–weight illusion still persists: when objects of identical mass but different size were suspended from wires and pushed over a distance of 50 cm, the smaller object was consistently rated as heavier than the larger one [11]. The material–weight illusion can also be induced without visual information [10].

In clinical practice, children presenting with LBP sometimes highlight the weight of the school satchel in connection with their problem, but almost never mention the carrying of other bags such as their sports bags. It might be that the school bag is inadvertently associated with activities considered to be an obligation, and is hence viewed negatively, whilst the sports bag, being associated with leisure-time activities, is carried with a more positive attitude. This may be the case, in particular, in those

adolescents who are actively engaged in competitive sport. We therefore set out to evaluate the influence of the “container” on the perceived weight of loads. We hypothesised that adolescents’ perceptions of the magnitude of a weight/load are influenced by: (1) the presence of LBP (heavier with LBP); and (2) the nature of the load lifted (a sports bag being perceived as relatively lighter than a school bag).

Material and methods

Subjects

Participants comprised male adolescent members of the local ice hockey and swimming clubs. These clubs were chosen on the basis of their being established organisations in our region, with whom we had existing contact. Candidates participated in regular training sessions and had a licence to participate in competitions. The clubs’ coaches identified potential participants and acted as an intermediary between the study manager and the parents of the athletes. The latter were provided with written information explaining the nature of the tests and the harmless nature of the study. The letter briefly described the outline of the study without divulging the main hypothesis. As the participants were minors, parents were required to sign the letter and send it back to the coach, confirming agreement of their child’s participation. None of invited athletes refused to participate.

Procedure

The tests were performed in the cloakroom of the local club for ice hockey players and on the pool deck for swimmers. A brief questionnaire enquired about the individual’s LBP status, in terms of whether they had suffered LBP in the previous year. Those answering in the affirmative were further questioned on the occurrence of the last episode, with the following response options: in the previous week; more than 1 week but <1 month ago; more than 1 month but <3 months ago; and more than 3 months ago. They were also asked whether their back problem had required medical attention and/or interfered with their sporting activities (in order to identify “consequential” or “non-trivial” LBP). Exclusion criteria were: pain other than LBP, and age <9 or >17 years.

The testing procedure involved three types of bag that were readily identifiable: a school satchel, a sports bag with the logo of a known brand, and a “neutral” bag, i.e., a bag typical of a shopping bag, not branded with any logo or any other tag. For each bag, two different weights were presented in a blinded manner, and the participants were asked

Fig. 1 Relative over/underestimation of the bag's weight for the light and heavy loads in relation to type of bag and LBP status (see text for details)

to estimate the weight of the bags. We aimed to obtain global weights (bag plus load) as close as possible to 2 and 5 kg for each type of bag.

The participants were free to grasp the bags as they wished (e.g., with one or two hands, over the shoulder, etc.) and were asked to estimate the weight as precisely as they felt confident of doing. For training/guidance purposes, known weights (dumbbells of 1 and 2 kg) were available for comparison with the bags at all times during the test, except when holding the bags. The time allowed to estimate the weight of the bags was not restricted. The observer gave a brief demonstration prior to the test. No feedback was provided concerning the accuracy of the estimations, either during or upon completion of the test.

The bags were presented on a bench 1 m above the ground, and in the same order for all participants, i.e., school satchel, sports bag, and neutral bag. After giving his estimation of the weight of the first bag, the participant put the bag back on the bench and started the procedure with the second bag. While the weight of the second bag was being evaluated, the examiner changed the load in the first bag. The participant was not aware of whether the load was being increased or decreased. The loads were presented in a random order, defined by a computer-generated list. Throughout the study, the participants were blinded to the exact weight of the bag and to the specific purpose of the experiment. The same examiner conducted all tests using the same protocol.

Statistical analysis

Descriptive data are presented as means and standard deviations (SD), unless stated otherwise. The difference between the actual and the estimated weight was expressed as a percentage of the actual weight, to indicate the “discrepancy” for the estimated value (overestimation or

Table 1 Comparison of actual and estimated weights of the loads in individuals with (LBP) and without (no LBP) a history of relevant LBP

	Estimated weight of bag (kg)			
	LBP		No LBP	
	Mean	SD	Mean	SD
Light load				
School bag (3.2 kg)	2.7	1.3	2.8	1.1
Sports bag (2.8 kg)	1.5	0.8	1.6	0.8
Neutral bag (2.2 kg)	1.5	0.8	1.7	0.9
Heavy load				
School bag (5.6 kg)	5.6	1.9	5.3	1.6
Sports bag (5.7 kg)	5.9	2.2	5.2	1.6
Neutral bag (5.2 kg)	5.9	2.9	4.9	1.8

underestimation with respect to the true weight). To compare the accuracy of the weight estimates in relation to history of relevant LBP, type of bag and magnitude of load, “discrepancy” values were analysed using repeated measures ANOVA [one between-factor (LBP) and two within-factors (bag type and weight)]. The significance of main effects and interactions was reported and Fisher's PLSD post hoc tests were used to identify the location of any significant differences. The analyses were carried out using Statview 5.0 (SAS Institute Inc, San Francisco, USA). p values <0.05 were considered to be statistically significant.

Results

Eighty boys with a mean age of 13.9 years (range 9.1–16.9 years) were included in the study: 36 of them were ice hockey players and 44 were swimmers. “Consequential LBP” was reported by 21/80 (26.2 %). The majority of these (57.1 %) had their last episode of LBP more than 3 months ago, while the remainder had their last episode more than 1 month but <3 months ago (14.3 %), more than 1 week but <1 month ago (9.6 %), or <1 week ago (19.0 %).

The mean (SD) values for the estimated weights under each of the conditions are shown in Table 1. The relative degree (%) to which the weights was underestimated or overestimated under each test condition are summarised in Fig. 1.

The main effects analyses from the ANOVA revealed that, overall, estimation of the load's weight was significantly more accurate ($p < 0.0001$) for heavy than for light loads (2.8 versus 26.8 % underestimation of the actual weight, respectively). The type of bag significantly ($p < 0.0001$) influenced the accuracy of the weight

Fig. 2 Dependence of the degree of over/underestimation on the heaviness of the load and the history of LBP

estimation, with the true weight being underestimated by 8.3 % for the school bag, 23.7 % for the sports bag and 12.4 % for the neutral bag.

The ANOVA revealed a significant interaction ($p = 0.024$) between LBP history and the heaviness of the load: those with a LBP history tended to overestimate the weight of the heavier load (by 5.7 %) whereas those with no LBP history underestimated it (by 5.8 %), with little difference between groups for the lighter load (Fig. 2).

Discussion and conclusions

Main findings

The aim of the present study was to examine whether adolescents' perceptions of the weight of a load were associated with the presence of LBP and the nature of the load lifted.

Compared with LBP-free adolescents, those with a history of LBP were found to overestimate the weight of the heavier bags that they were presented with. Further, in the group as a whole, the heaviness of the sports bag was underestimated to a greater extent than that of either the neutral bag or school bag.

The subjective perception of “load heaviness” is a relevant theme in schoolchildren as it has been shown that both the perceived weight and perceived fatigue during carriage of the school bag are significantly associated with back pain [12]. Possible explanations for this include a diminished physical capacity (back strength, endurance) associated with LBP, rendering the same absolute load relatively heavier for individuals with LBP compared with their LBP-free counterparts, or an increased tissue sensitivity to load associated with LBP, with the consequent perception that the bag is heavy, fatiguing and painful [12].

Either of these explanations could account for the findings in the present study of a tendency for the children with LBP to overestimate the weight of the heavier load. Studies on adults have revealed that, compared with asymptomatic individuals, individuals with LBP experience greater spine compression and shear forces when performing lifting tasks, predominantly due to greater co-contraction of antagonist trunk muscles [13]. This in itself would also lead to a given load “feeling heavier”.

It has also been suggested that psychological factors such as fear avoidance may influence load perception in individuals with LBP [14]. Our volunteers were actively involved in sport and were evaluated during a regular training session; hence, although we cannot rule out a role for kinesiophobia, we consider it a relatively unlikely explanation for the findings. Future studies should attempt to unravel the relative importance of physical and psychosocial factors related to the perception of loads in schoolchildren.

As originally hypothesised, the adolescents in the present study—who were all actively engaged in competitive sport—underestimated the weight of the sports bag to a greater extent compared with either the school bag or a neutral bag. We made no attempt to standardise the three bags for size, density, handling etc.; on the contrary, the intention was to keep the bags in their normal, recognisable state in order to highlight the visual association with their daily utilisation (i.e., school or sports activities).

One of the premises upon which our hypotheses were based was that the volunteers likely enjoyed sporting activities more than they did school. However, this was an a priori assumption that could not be verified, as we did not gather specific information on how much our subjects enjoyed attending school. The study simply aimed to explore whether or not the association of the bag with a scholarly activity rather than a leisure-time activity might influence weight perception. Being keen sportsmen, we considered it fair to assume that the adolescents were less likely to view the sports bag as a threatening load. We therefore suspect that in the present study the differing perceptions of load were influenced by the volunteer's (possibly subconscious) judgement regarding the desirability of the activity for which the given bag was intended. Other possible explanations include greater familiarity with lifting/carrying a heavy sports bag in an efficient manner (e.g., keeping it closer to the body), such that it demands less muscle recruitment and feels lighter compared with the other bags, or simply greater comfort holding the sports bag than the other two bags. Either way, the findings suggest that, when attempting to prevent LBP in adolescents, we should be cautious in setting maximum weight limits for the carrying of school bags until the true mechanical role of the load, as opposed to its perceived

weight, has been clarified. Interestingly, in Negrini and Caraballona's [5] study, neither the actual backpack weight/body weight nor the carriage time showed any significant correlation with backpack-related pain, although fatigue during backpack carrying did. Further, the finding that the amount of time that schoolchildren spend carrying their bags is typically relatively short, with 84 % carrying it for <15 min a day, would also seem to challenge the role of objective biomechanical loading [15].

Strengths of the study

The study included boys from the same small geographical region, active in sport within local organisations. As such, this was quite a homogeneous population in terms of educational and socio-economic background. All the tests were performed by the same researcher who went to the clubs' facilities with the agreement of the coaches. The loads were chosen based on previously published studies [16, 17] as well as our own preliminary tests, and we were confident that participants were not subject to any unacceptable risk in lifting them. None of the subjects reported any discomfort during the tests. A previous study has shown that 10-year-old children (i.e., younger than our subjects) are capable of translating into numbers their perceptions of physical exertion and that weights similar to those used in the present study correspond to the low perceptual anchor on perceived exertion scales [18]. In another study, young adults were capable of discriminating between loads with as little as 40 g difference in weight, under strict experimental conditions [19]. Overall, the accuracy of the estimates in the present study was comparable to those reported in the literature, although no previous studies have used an identical design to ours. Karwowski et al. [20] studied the role of psychophysical variables in discriminating load heaviness in young adult males and reported that the error in discriminating between two successive loads was below 10 %, if the difference between the loads was at least 12 % (or 1.8 kg).

Weaknesses of the study

The study was limited to boys and the findings might not be applicable to girls. In view of the sporting level of the current participants, the findings may not be applicable to either high-level sportsmen or beginners or to sedentary adolescents. Moreover, it is difficult to know whether the findings would have been different, had other types of sports players been studied. Finally, we did not evaluate the participants' perceptions with respect to their enjoyment of school and sporting activities, which may not necessarily have differed.

In conclusion, our study demonstrated a significant difference between the containers used in relation to adolescents' perceptions of load heaviness. Further, a history of LBP appeared to influence this perception. Until we have a better understanding of the mechanical role of the backpack weight versus the perception of its weight in the aetiology of LBP, any recommendations about the schoolbag weight limit should be viewed with caution.

Conflict of interest None.

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