An Educational Exercise on Backpacks for School Children:
Including Children, Faculty and Parents

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ABSTRACT

The purposes of this study were to increase backpack awareness among students, introduce ergonomics and research to 8th graders, and to investigate backpack use and wear among students at a private elementary school (n = 88). For the majority of students (55.7%) schoolbag weight was ≤ 10% of their body weight. However, schoolbag weight was ≥ 10 and ≤ 15% of the body weight for 30.7% of students, ≥ 15 and ≤ 20% for 12.5% of students, and > 20% for 1% of the students. These weights exceed the recommended guidelines provided by several American Medical and Allied Health Professional Societies.

Keywords

Backpacks, ergonomics, children, musculoskeletal injury

INTRODUCTION

Carrying school supplies and books in a backpack can result in physical strain on a child. Studies have found backpack weight to range from 7.7% to 9.6% of children's body weight to 12% (Chiang, Jacobs and Orsmond, 2006; Forjuoh, 2004; Forjuoh, Lane, Schuchmann, 2003). Children tend to perceive of their backpacks as heavy, to cause fatigue and even to cause back pain, and their perceptions are related to their back pain, however it is less clear how backpack weight is associated with pain (Negrini and Carabalona, 2002). Yet, associations have been found between backpack weight and self-reported back pain weight (Chiang, Jacobs and Orsmond, 2006). Studies have found children's back pain to be associated with more frequent use of back packs and carrying significantly heavier backpacks (higher percent of body

weight) (Sheir-Neiss, Kruse, Rahman, Jacobson, and Pelli, 2003; Skaggs, Early, D'Ambra, Tolo, and Kay, 2006; Viry, Creveuil, and Marcelli, 1999). Korovessis and colleagues found that children who are shorter in stature and carry backpacks as heavy as taller children at the same age reported experiencing more low back pain (Korovessis, Koureas, and Papazisis, 2004). Still, the topic remains controversial regarding as questions remain over whether the pain is temporary and if the length of time carrying heavy packs is sufficient to cause permanent changes in skeletal structure.

Back pain has been reported in children from 11 – 14 yrs of age at 37% (Skaggs, Early, D'Ambra, Tolo, and Kay, 2006) and up to 74% of 12 to 18 year olds surveyed (Shier-Ness, Kruse, Rahman, Jacobson, and Pelli, 2003). The finding of 74% seems to be a rather high percentage of the population, yet this was validated by affirmative answers from the children indicating poorer general health, limitation in physical functioning, and more frequent reports of pain (Shier-Ness, Kruse, Rahman, Jacobson, and Pelli, 2003).

Of course, not all back pain is related to back pack use. Research by Hakala and colleagues found pain in the neck, shoulder and lower back is increasing among Finnish children between the ages of 12 and 18, with the risks being higher for girls and for older children (Hakala, Rimpela, Salminen, Virtanen, and Rimpela, 2002). However, increases appear to be associated with computer use (Hakala, Rimpela, Saarni, and Salminen, 2006).

Risk factors for back pain among children include being female, age (more frequent in adolescents than in children), a family history of back pain, history of spinal trauma, time sitting and watching television intense physical activities including competition sports, and specific psychological configurations (Cottalorda, Bourelle, Gautheron, and Kohler, 2004). Other studies report similar findings regarding the amount of time sitting (Grimmer and Williams, 2000), playing sports (Grimmer and Williams, 2000; Kovacs, Gestoso, Gil del Real, Lopez, Mufraggi, and Mendez, 2003), psychologicial or psychosomatic factors (Siiyola, Levoska, Latvala, Hoskio, Vanharanta, and Keinanen-Kiukaanniemi, 2004; vanGent, Dols, Rover, HiraSing,and deVet, 2003), younger age (Skaggs, Early, D'Ambra, Tolo, and Kay, 2006; Vikat, Rimpela, Salminen, Rimpela, Savolainen, and Virtanen, 2000) such as being more frequent among teens vs. pre-teens (Sheir-Neiss, Kruse, Rahman, Jacobson, and Pelli, 2003), and girls reporting pain more often than boys (Korovessis, Koureas, and Papazisis, 2004; Kovacs, et al., 2003; Sheir-Neiss, Kruse, Rahman, Jacobson, and Pelli, 2003; Skaggs, Early, D'Ambra, Tolo, and Kay, 2006; Viry, Creveuil, and Marcelli, 1999; Vikat, Rimpela, Salminen, Rimpela, Savolainen, and Virtanen, 2000). Other researchers have not found the same differences according to age or between adolescents and younger children (Korovessis, Koureas, and Papazisis, 2004).

Height, body weight and kyphosis, lordosis, and scoliosis did not correlate with back pain in one study (Korovessis, Koureas, and Papazisis, 2004), yet scoliosis (Skaggs, Early, D'Ambra, Tolo, and Kay, 2006) as well as a difference in leg length were associated with back pain in another (Kovacs, et al., 2003). Still another found a larger body mass index associated with back pain (Sheir-Neiss, Kruse, Rahman, Jacobson, and Pelli, 2003), while Kovacks and colleagues did not find children's back pain to be associated with body mass index, the manner in which books were transported, hours of leisure sitting, or alcohol intake or cigarette smoking (Kovacks, et al., 2003).

The location of pain among children appears to vary by age. Korovessis and colleagues found "dorsal pain" to peak at age 11 for both girls and boys and "low back pain" peaking at age 11 for girls and at age 15 for boys (Korovessis, Koureas, and Papazisis,

2004). These peaks in pain occurred just before and just after puberty. Perhaps most important is the finding that pain during youth is associated with pain as a young adult (Siiyola, et al, 2004). Hakala and colleagues suggested this might be indicative of "a new disease burden of degenerative musculoskeletal disorders in future adults" (Hakala et al, 2002). Yet, how much is too much to carry? While some groups estimate the maximum a child should carry at 10% of their body weight, others suggest the weight should not be more than 20%. According to Negrini, Carabola, and Sibilla (1999):

> The average load and maximum load being carried by children are equivalent to an 80 kg man carrying daily a backpack with an average load of 17.6 kg and a maximum load of 22.0 kg (or for a 60 kg woman, 13.2 kg and a 16.5 kg, respectively). In Italy, labor laws restrict the maximum load that can be lifted during work to 30 kg in men and 20 kg in women. The limits are 20kg and 15 kg for workers aged 15-18 years. The USA recommended limit for adults is 23 kg, which is deemed to protect 99% of men and 75-90% of women. No limits have been developed for application in schools; the limits usually proposed for children, although scientifically unproven, (10-15% of bodyweight) are widely exceeded in everyday life.

Pack weight varies considerably by country (Forjuoh, 2004) and some researchers have found that packs get heavier as children age, from 6.2% among kindergarteners to 12% among 5th graders (average being 8.2%) (Forjuoh, 2004; Forjuoh, Lane, and Schuchmann, 2003). Other research found backpack weight stayed approximately as the same for younger and older students when all were adolescents (Grimmer and Williams, 2000). Girls are apt carry heavier packs than boys (Forjuoh, 2004). Thus, while a general backpack education program should be beneficial for any schools teachers, students, and parents, a focused intervention in which information is gathered from the existing students would seem to hold more meaning.

The primary purposes of this study were to increase backpack awareness among students, introduce ergonomics and research to 8th graders, and to investigate backpack use and wear among students at a private elementary school. Secondarily, but no less important, were the goals to increase awareness among educators and parents.

PARTICIPANTS

Participants included 88 children (37 boys and 43 girls) from kindergarten through eighth grade, at a private school in San Antonio Texas. School officials sent a flyer home with students prior to data collection explaining the nature of the study and that participation by their children was voluntary.

PROCEDURE

Students in the 8th grade science class were visited by researchers a few days prior to the data collection. A basic introduction to human factors/ergonomics, research, research methods and data collection was provided. Specific information about the backpack study was also provided, including a review of the questionnaire and demonstrations of interviewing techniques, taking weights, and measuring heights. In a subsequent meeting, the 8th grade class practiced doing all measures for the study. The students' teacher re-emphasized the learning experience by having the students discuss research, data collection, data recording, and data displays during class, as well as having them write a short report regarding the research experience.

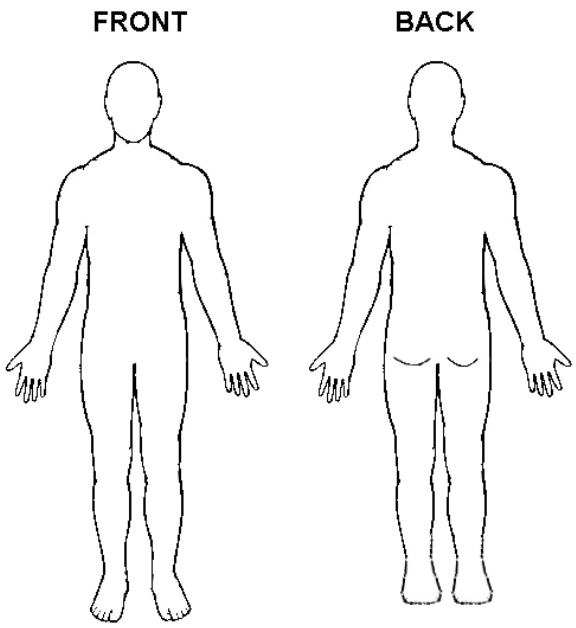
Data was collected during before school care over three days, with 8th grade students assigned to one of five tasks: escorting subjects to and from the study area, compiling

and checking data forms, interviewing, measuring student height, or measuring student and backpack weights. The volunteer 8th grade students recruited participants from the main cafeteria room at the school and brought each student to the area where the interviewing and measures took place. All procedures were supervised by participating researchers. A copy of the data was given to the 8th grade students so they could also compute the descriptive data during science class.

METHODS

Participants were asked to fill out the top of a feedback paper with their birth date, gender, and grade level. If the participant needed help (such as with younger children who could not read or write), the 8th grade volunteer would elicit this information verbally and record it for them. Height was measured without shoes and weighed twice, without shoes, once while wearing their backpack and once without the backpack.

During the interview, each participant was asked a series of questions including information on the type of pack used, how they typically wear their pack, who selected the pack, the criteria used for selection of the pack, and whether they had adjusted the pack to fit them. They were also asked to annotate any musculoskeletal soreness, pain, or discomfort they were currently feeling or that occurred on a regular basis. Participants marked their soreness, pain or discomfort on a whole body diagram, rated it on a 10 point scale, and described it in terms of frequency (how often does it occur in terms of days per week) and duration (how long they had been experiencing the pain). As subjective rating systems are not equally sensitive in distinguishing comfort, both a visual analog scale and an anatomical illustration scale were used (Jacobson, Oney, Redus, Edgley, Kulling, and Gemmel, 2004) (Figures 1 and 2).



Location #1 Intensity?
_____

Location #2 Intensity?
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Location #3 Intensity?
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Location #4 Intensity?
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Figure 1. Whole Body Diagram

Using this 0 to 10 scale, please rate the soreness, pain, or discomfort you indicated above.

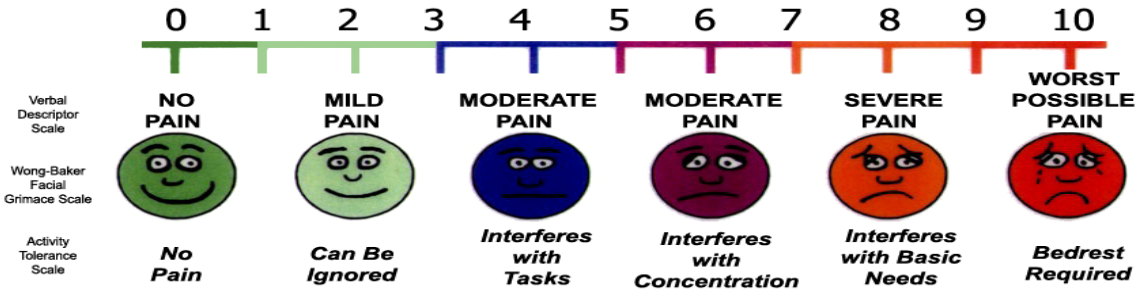

Figure 2. Visual Analog Scale

Descriptive statistics were used to describe the results, while Chi2 statistics were used to compare soreness, pain and discomfort symptoms by age and percent of body weight carried.

RESULTS

Musculoskeletal symptoms were reported by 32% of the students. The distribution of the pain can be seen in Table 1.

Table 1. Distribution of Pain Among Children Reporting Pain (percent of total reported musculoskeletal symptoms).

Body Part	Percent
Head and Neck	6.5%
Shoulders	54%
Abdomen	2.2%
Back	28.3%
Legs	6.5%
Hand	6/5%

Of the total reported symptoms, the intensity was described as 1-2 for 39%, 3-4 for 29.3%, 5-6 for 24.4% 7-8 for 4.9% and 9-10 for 2.4%. The duration of symptoms ranged from a few days (6.1%), a few weeks (30.3%), a few months (9.1%), 6 months (15.2%, described as since the beginning of the school year), to a year or more (36.4%). The remaining 2.9% were simply described as "long" by young kindergartener. The frequency of pain reported per week is shown in Table 2.

Table 2. Frequency of Occurrence of Pain (% of total reported musculoskeletal symptoms).

Frequency	Percent
1-2 days/week	28%
3-4 days/week	32%
Daily	40%

Pain was reported more often by older children, compared with younger children: Kindergarten – 2nd Grade (14.8%), 3rd – 5th Grade (27.8%), and 6th – 8th Grade (57.4%).

The majority of children carried a double strap pack (n = 72) with others carrying a sling style (n = 14), one using a roller bag, and one not reporting the pack type. Of the children carrying a double-strap pack, 26% reported soreness, pain or discomfort while 50% of those carrying a sling pack reported symptoms. Most children with a double strap pack carried it over both shoulders (83.3%) compared with 8.3% who carried it over one shoulder, 1.4% who carried it in one hand, and 6.9% who

alternated carrying it over either one or both shoulders. Using wheeled packs was not permitted at this school without special permission.

The number of boys and girls participating by grade, backpack weight, and backpack weight as a percent of body mass can be seen in Figure 3.

Demographics

	Boys	Girls	??		BACKPACK WEIGHT min.	BACKPACK WEIGHT AVG	BACKPACK WEIGHT max.	BACKPACK AS % of BODY WEIGHT 0% to ≤ 10%	10% to ≤ 15%	15% to ≤ 20%	> 20%
Pre-K	0	4	1	5	1.20	2.20	3.00	5	0	0	0
Kindergarden	3	6	2	11	0.20	1.89	3.20	11	0	0	0
1st grade	3	2	0	5	2.20	5.92	8.00	2	3	0	0
2nd grade	3	2	0	5	1.40	8.36	11.00	1	0	4	0
3rd grade	6	6	1	13	1.80	7.12	9.60	18	6	2	0
4th grade	2	7	1	10	4.40	7.54	11.20	5	3	2	0
5th grade	3	3	1	7	1.20	6.33	12.00	5	2	0	0
6th grade	3	2	0	5	6.20	12.28	16.60	1	3	1	0
7th grade	5	6	2	13	3.20	11.78	21.60	5	6	1	1
8th grade	9	5	0	14	6.60	11.32	17.00	9	4	1	0
	37	43	8	88	0.20	7.83	21.60	49	27	11	1
								55.7%	30.7%	12.5%	1.1%

Figure 3. Demographics by gender, backpack weight, and weight as a percent of body mass

As seen, 44.3% of children were carrying backs that were greater 10% of their body weight. Pack weight, student weight, and pack weight as a percent of body weight are seen in Figure 4.

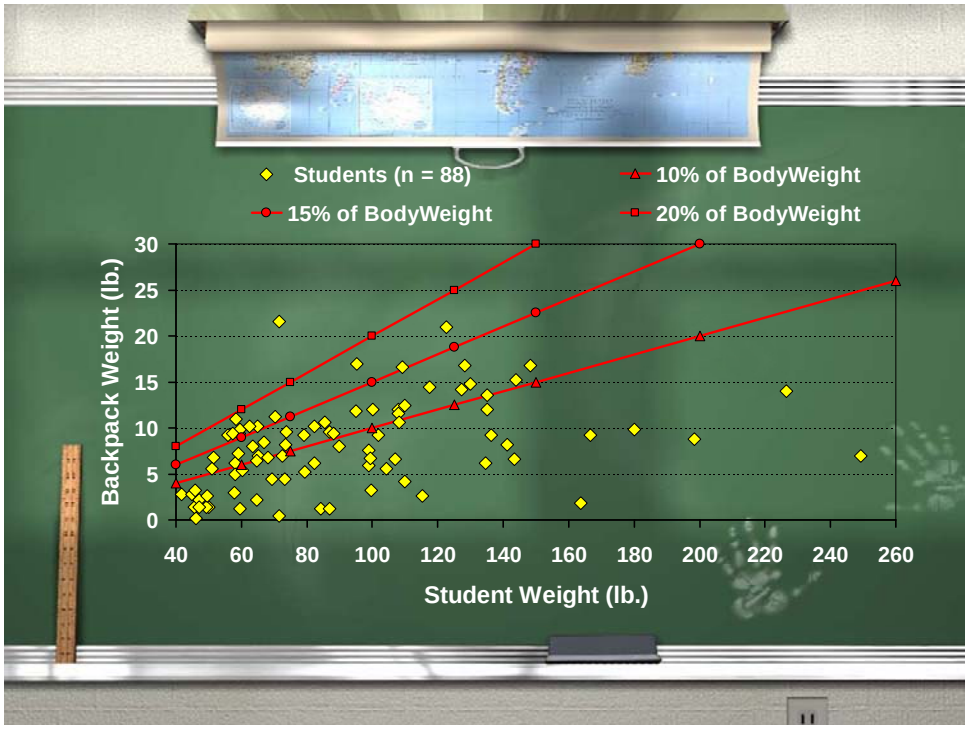

Figure 4. Backpack weight, student weight, and pack weight as a percent of body weight.

In general, pack weight tended to increase with body weight.

There was no difference in soreness, pain and discomfort reported when comparing those carrying 10% of less than their body weight with those who carried more than 10% (Chi2=2.027, p=0.15). Girls did not report pain more often than boys (Chi2 =0.309, p=0.58).

Eighth graders put their packs into a designated area in their homeroom and carry their books to each of their classes by hand. Weights carried by hand while changing classes were ≥ 10% of students' body weight for 75% of 8th grade students.

The child him or herself selected the majority of the packs (56.8%), while mothers selected 29.5%, fathers 3.4%, and other 10.2%. Packs were selected most often on the basis of color (31.8%) and designs on the pack (11.4%) and size (10.2%), with many children being unable to answer the question, especially if the pack was selected by someone other than themselves (37.5%). Most of the children reported adjusting the pack straps to fit them (70.4%), with 26.1% not doing any adjustments and 3.4% not reporting the information.

DISCUSSION

Approximately a third of students reported soreness, pain or discomfort, which is slightly less than the 36% found by Skagges and colleagues (2006). Pain was reported primarily in the shoulders and back and most pain was considered low to moderate. These findings support studies suggesting the 'weak point' when carrying backpacks may be the shoulder and not the back (Cottalorda, Bourelle, Gautheron, and Kohler, 2004).

Symptoms occurred equally either over 1-2 days, 3-4 days or daily and most had been present for either a year or more or slightly less frequently for only a few weeks. Unfortunately, the concept held by adults is that children are adaptable, their pain temporary, and the rapidity of their growth preclusive to designing products that actually fit their body size and structure. Yet few adults would ignore their own pain, especially if occurred frequently for a long period of time.

Pain was reported more often among older children, as has been found among a number of other researchers (Cottalorda, et al. 2004; Sheir-Neiss, et al. 2003; Skaggs, et al. 2006; Vikat, et al. 2000). Not all research has found differences according to age (Korovessis, et al. 2004). Girls did not report pain more often than boys, differing from findings from other research (Cottalorda, et al. 2004; Korovessis, et al. 2004; Kovacs, et al., 2003; Sheir-Neiss, et al. 2003; Skaggs, et al. 2006; Viry, et al. 1999; Vikat, et al. 2000).

Most children used a double strap back pack over both shoulders. Those carrying a sling type pack reported experiencing soreness, pain or discomfort nearly twice as often as children using double strap packs. Although the number of children carrying sling type packs was small, these findings along with observations of leaning among children carrying sling packs and studies on adults carrying one-sided packs should encourage parents to forego these packs.

While the majority of students carried packs weighing 10% or less of their body weight, there was still a large percentage of children that carried packs greater than 10% of their body weight. In fact, the findings from this study found a higher percentage (44%) of students carrying packs weighing greater than 10% of their body weight than previous studies that found up to 26% of students carried weights up to or greater than 10% of their body weight (Forjuoh, 2004; Forjuoh, Lane, and Schuchmann, 2003). Solutions to decrease the weight of packs include having two sets

of books, one for work and one for school; putting books and school work onto CDs; providing lockers; and having children use wheeled packs.

Pack weight tended to increase with age, which might also explain why pain was reported more often among older children. There was an even greater percentage of students among 8th graders who carried weights from class to class by hand that was equal to or greater than 10% of their body weight, than those carrying packs. One fairly easy way to deal with this is to permit students to go to their homeroom (or locker) more often in order to decrease their load.

A small number of children use wheeled packs with researchers approximately 3.5% of children using them (Forjuoh, 2004; Forjuoh, Lane, and Schuchmann, 2003). Typically, children using wheeled packs reported doing so due to concern about pack weight and the children selecting wheeled packs tended to be older and female (Forjuoh, Lane, and Schuchmann, 2003). It may also be true that some schools encourage (Forjuoh, Lane, and Schuchmann, 2003) or discourage their use due to a concern over crowded hallways and possible trip hazards. However, no published data on injuries due to trip hazards are noted in the literature to date.

The children in this study selected their pack primarily based on the way it looked, citing color and decorations most often. It appears that students change their minds after using the pack for a period of time and become more interested in the function and comfort of the pack (as shown by Mackie, Legg, Beadle, and Hedderly, 2003), however it is unlikely their parents will want to purchase a second pack anytime soon, unless the first purchase actually breaks. Thus, we are left with the question of how to influence both children and their parents in the purchase of a pack that offers better support and comfort.

Fortunately, most children did adjust the pack to fit them. One child mentioned that his physical education teacher ("coach") reminded him to adjust his pack, and to readjust it if the straps became loose. Thus, it appears that students in this school have received some education regarding backpack use.

In conclusion, just less than half of the students at this school were carrying packs considered too heavy for them. Carrying heavy packs appears to contribute to short term soreness, pain and discomfort. Certainly, carrying heavy packs can result in posture alterations and may influence skeletal growth with long term exposure. While the long term effects of the association between backpack carrying and back pain are unknown, surely the mere fact many researchers have found an association between pack weight and pain will encourage parents, teachers, and school administrators to decrease the weight of backpacks or the weight carried in the arms.

Including students as co-researchers helps them to understand research, feel ownership of the project, and mentor younger students in backpack fit and use. An additional follow up in this situation is providing a final report to the school and a handout on backpack recommendations for parents.

LIMITATIONS

Limitations include the limited number of students per grade and potential mistakes incurred during the use of volunteer 8th grade assistants. However, in the latter limitation, the gains of involving the students were considered to outweigh the risks.

RECOMMENDATIONS

Several specific recommendations were provided in the discussion. In addition to those, one of the most important recommendations is to use a macroergonomic approach and involve all pertinent groups, including the children themselves, their

parents, educators, the school system, and the community. More specific suggestions include having a backpack awareness day at school that includes fitting assistance, weighing packs and students, and perhaps a poster competition. Older children can help collect and tabulate the data, younger children can create the posters, local community members can judge the posters, and local business can support the effort potentially by awarding poster winners with an ergonomically designed pack. Older children can also help design flyers for parents or for community publications.

Coaches and science teachers are very important in the effort as they can teach the children what happens physically when a child carries a heavy pack. Science and math teachers can use the opportunity to show children how the combined use of science and math can answer practical questions relevant to daily life.

FURTHER RESEARCH

The most important future need is longitudinal research identifying the impact of carrying heavy packs during youth on posture, spinal structure, and pain during adulthood.

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