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Adolescent Back Pain and Associated Backpack Loading, Locker Use, and Online Textbook Alternatives

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Abstract

Background: The incidence of childhood back pain is well established. The purpose of this study was to explore relationships between adolescent back pain and characteristics of load carrying, and behaviors such as locker and online textbook use.
Methods: Data was collected from adolescents at three different schools. Students and their backpacks were weighed to determine backpack weight relative to body weight (RBW). Students completed a written survey designed by the authors; the survey gathered details of backpack wear and usage including carry time, activity level, locker use, and potentially associated back pain.
Results: A majority (66.7%) of students (N = 78) reported back pain. Discriminant function analysis revealed RBW does not predict reported frequency of back pain (P = 0.96), nor did the percent of online textbooks (P = 0.23). However, a crosstab analysis showed that adolescents who carried a loaded backpack more frequently between classes reported greater frequency of back pain (P = 0.001).
Conclusions: Back pain is a noted complaint amongst adolescents. The results of this study challenge the literature highlighting RBW as responsible for back pain in adolescents and asserts, instead, that longer wear time attributed to infrequent locker use for storage is responsible for back pain in this middle school sample of adolescents. Students should be encouraged to use lockers between classes to decrease carrying time of loaded backpacks.

Keywords: Backpack, Relative Backpack Weight, Adolescent Back Pain

1. Background

Growing evidence recognizes that more children are experiencing back pain (1, 2). In fact, a reported 77% of seventh and eighth graders reportedly experience back pain during the school year (3). There is evidence to suggest that a prior episode of low back pain (LBP) may predict subsequent episodes of LBP (4) and that adolescents who experience low back pain are more likely to have back pain as adults (4, 5). Evidence also supports the notion that heavy backpacks contribute to childhood back pain (6-9). Forty-four percent of students report discomfort carrying their backpack (8), and 82% of children who complain of pain attributed their pain to backpack wear (5); most adolescent subjects report relief from pain after removing their backpack (6).

Recommended backpack weights are calculated as a percentage of body weight. The relative backpack weight (RBW) recommendation varies depending on the source of the suggestion. The American Physical Therapy Association (APTA) endorses a RBW of 10% - 15% (10) while the American Occupational Therapy Association (AOTA) recommends a backpack weight of no more than 10% of the child's weight (11). In contrast, the American Chiropractic Association (ACA) recommends a backpack weigh no more than 5% - 10% RBW (12). Poor consensus about RBW recommendations complicates decision-making about backpack wear for students, educators, and parents. Yet, the concerns about carrying load are sufficient enough that the Association for Middle School Education has called for health agencies to generate informed and consistent recommendations in an effort to assist school officials in developing policies that foster health and wellness (13).

Upper- and mid-back pain has been associated with an increased RBW (7). Numerous studies of school-aged children report that children commonly carry backpack loads above 15% RBW (8, 14-16). Negrini and Negrini (14) documented a 21% RBW average weekly load with a maximum load of 27%. Goodgold and Nielsen (8) demonstrated that 50% of subjects wore backpack weight in excess of 15% RBW. Of significance, researchers (16) have associated respective increase in back pain with backpack loads representative of 10%, 20%, and 30% RBW. In fact, an association between back pain and a backpack weighing more than 15% - 20% RBW has been postulated (9).

Some researchers have expanded their investigations to understand how an increase in backpack weight increases frequency of back pain (8, 14). Magnetic resonance imaging (MRI) shows significant compression of the spaces between the lower back vertebrae and a decrease in

the symmetry of backbone alignment with application of increasing backpack loads while standing (16). Reports of back pain in children are strongly correlated with a loss in the normal spacing between vertebrae in the low back or changes in the normal curves of the back in response to backpack load (16). Research has linked an increased forward head posture to an adolescent's carrying a backpack at 15% RBW (17).

Research has demonstrated that as the body reaches its load tolerance capacity, postural changes are observed in as little as seven minutes (8) carrying a load (14). In fact, it is known that loaded backpack weight, length of carry time, and method of transportation to school impact back and neck pain (18). Additionally, fewer incidences of back pain are observed among those who carry a backpack for five to ten minutes compared to fellow students carrying backpacks for a longer period of time (18). Chiang and associates (19) found that daily backpack carrying was a frequent cause of musculoskeletal discomfort among those 13 - 14 years of age. The association between backpack carrying time and low back pain was strong enough for the authors to recommend lessening the length of time this population carried a backpack (19).

Factors that may affect carry time and influence backpack wear include the use of school lockers, transportation, and activity level (1, 6-8, 14, 18). Goodgold and Nielsen (8) stated 35.7% of students did not place backpacks in a locker for storage during the day, for reasons unknown to the researchers. Further findings include fewer back pain complaints for children who have access to lockers (5).

2. Purpose

A paucity of research exists studying specific environmental characteristics of the school setting or access to technology and their potential effects on backpack use and back pain. The literature points to a need for studies expanding our understanding of school-related influences on backpack carrying behaviors and student reports of back pain. Current literature provides evidence that a relationship between reports of childhood back pain and relative backpack loads exist (1, 5, 6, 14, 18). A growing amount of evidence also supports the ability to predict subsequent adulthood back pain based upon childhood reports of back pain (4, 5). The purpose of this study was to ascertain whether such factors as backpack utilization (i.e., loading, wear duration), choice and frequency of locker use for book and supply storage, and online text availability as an offload strategy predicted the occurrence of back pain among adolescents.

3. Methods

This cross-sectional study was approved by the university's institutional review board (IRB), and procedures were in accordance with the ethical standards of the affiliated university's IRB.

3.1. Participants

Participants were a sample of convenience based upon site investigator location in three regions (Pacific, West, and Midwest) in the United States. The sample included 6th, 7th, or 8th grade students enrolled in one of three school districts agreeable to participation. Subject recruitment was as similar as possible across the regional sites and began with permissions from district administrators to send a letter to the parents of middle school children, detailing participation specifics. All 6th, 7th, and 8th grade student students who carried a backpack and who were enrolled in a participating school were eligible and received an invitation to participate; however, at the Site C school district's request, invitations were only extended to 8th graders. Seventy-eight (38 female, 40 male; M = 13.01 years old, SD = 0.76 years) of 377 (20.7%) invited middle school children across the three sites completed both survey and weigh-in. A majority (61.5%) of the participants were recruited from a single site (Site A). The sample comprised disproportionately older students, with 83.3% of all subjects in the 8th grade. The sample size was determined adequate using alpha = 0.05, statistical power [1-beta] = 0.80, and r = 0.50 [associated with a large effect size].

3.2. Instruments

A scale was used to measure weight of child and backpack. Each site utilized the same scale model, a Health o Meter Professional model number 349klx, for measurements of weight.

A paper survey completed by the student comprised three demographic questions (grade, age, and gender) and several questions adapted from a survey developed by Mehta, Thorpe, and Freburger (3). The review of literature was used to develop additional questions about behaviors such as electronic textbook use, frequency of locker use, time offered between classes, frequency of computer use, and wear behaviors during transport between classes as well as to and from school. The survey also gathered details about the child's activity level, the existence of back pain, and the characterization of any back pain.

3.3. Procedure

Investigators at each data collection site received appropriate administrative approval, worked with a key contact person within the district to facilitate informational

meetings with students for recruitment purposes, and organized data collection details (such as school location and scheduling specifics). Compliance with school district expectations at three different sites across the country required unique procedures for data collection. Each school district requested minor variations concerning parent notification and time of day that researchers could access the subjects. The researchers adapted these requests to the planned procedures with as few across-site variations as possible to limit errors in construct validity.

On a pre-selected day, the site coordinator at each site met with students during a planned period, briefly talked about the study, answered student questions related to the study, and provided each student with an informational letter to parents, parental consent forms, child assent forms and the compiled survey. Interested students were asked to return signed parental consent forms and child assent forms as well as the survey to their teacher or to the study site coordinator either on or in advance of the specified data collection day. Students who did not complete the survey prior to data collection completed the form during the scheduled data collection period, depending upon the site.

Each participating child and each child's backpack were weighed. Measurements were taken in either a separate room or an area cordoned off from view of others to ensure privacy. The backpack weight relative to the child's weight, in percentage, was entered onto an informational brochure, and students were asked to review the information on the brochure with their parents or guardians later. When data was collected at multiple periods, the brochure was placed in an envelope and students were asked to wait to open the envelope until they were home. The use of a sealed envelope ensured that other students participating in the study would not have access to educational materials prior to the collection of their data. The backpack educational brochures were also available to those students in the class who did not participate in the research.

3.4. Data Analysis

Descriptive statistics (e.g., subject characteristics, pain frequency, relative backpack weight, and response frequencies) obtained from the survey were analyzed using SPSS version 24. Discriminant analysis was used to understand whether RBW or percent of online textbook use predicted reported frequency of back pain. A crosstab analysis was used to analyze frequency of carrying a loaded backpack between classes against reported frequency of back pain. Alpha was established at 0.05.

4. Results

Most students (76.6%) reported using a backpack to transport school-related materials between home and school "all of the time" and infrequently (62.8%) using a laptop computer, tablet, or IPad for school work.

Sixty-seven percent of all children reported back pain at least a few times each month (Table 1). More boys (40.0%) reported "never" experiencing back pain than did girls (31.6%). Fewer eighth grade students (60.0%) reported pain at least a few times a month than did younger peers (84.6%).

Table 2 depicts levels of RBW against student demographic frequencies. Approximately 10% of all students carried a backpack exceeding 15% RBW. Boys (20.0%) were more likely to carry backpacks with a RBW greater than 15% than were girls (7.9%), and 8th graders were more likely than younger students to carry a backpack greater than 15% RBW (15.5% of all 8th graders vs. 0.00% of all 6th and 7th grade students). The table also depicts pain frequencies against RBW. Of interest, 90.9% of those who reported back pain a few times each week and 100% of those who reported back pain every day carried a backpack load less than 15% RBW.

Discriminant analysis revealed neither RBW ($\lambda = 0.996$; $\chi^2 = 0.30$; P = 0.96), nor percent of online textbooks ($\lambda = 0.939$; $\chi^2 = 4.34$; P = 0.23) predicted reported frequency of back pain. However, a crosstab analysis (Table 3) showed that adolescents who carried a loaded backpack more frequently between classes reported greater frequency of back pain, with P = 0.001 (Table 4).

5. Discussion

The original investigation queried whether a backpack carrying load and duration, RBW, choice of locker use, or online textbook alternatives predicted the frequency of adolescent back pain. A majority of adolescents reported some level of back pain, demonstrating the prevalence of the problem and suggestive of the potential for lifetime back pain problems. With two-thirds of the sample population reporting some degree of back pain, the reported incidence of back pain transcended grade or RBW differences. Many past studies have determined a link between RBW and back pain in adolescence (6, 8, 9). The data collected for this study did not support the link between RBW and incidence of reported back pain.

This research lends evidence that carrying time, rather than carrying load leads to a higher reported frequency of back pain. The practical implications of this finding are important since many school districts are downsizing or eliminating lockers within schools due to space and safety considerations. Students are pressed to move

Table 1. Characterization of Back Pain Frequency[a]

	Frequency of Back Pain			
	Never	**A Few Times a Month**	**A Few Times A Week**	**Every Day**
All Children	28/78 (33.3)	29/78 (34.5)	10/78 (11.9)	11/78 (13.1)
Age, y				
10 - 12	1/9 (11.1)	5/9 (55.6)	1/9 (11.1)	2/9 (22.2)
13	21/53 (39.6)	18/53 (34.0)	7/53 (13.2)	7/53 (13.2)
14 - 15	6/16 (37.5)	6/16 (37.5)	2/16 (12.5)	2/16 (12.5)
Gender				
Boys	16/40 (40.0)	14/40 (35.0)	5/40 (12.5)	5/40 (12.5)
Girls	12/38 (31.6)	15/38 (39.5)	5/38 (13.2)	6/38 (15.8)
Grade				
6th - 7th grade	2/13 (15.4)	7/13 (53.8)	1/13 (7.7)	3/13 (23.1)
8th grade	26/65 (40.0)	22/65 (33.8)	9/65 (13.8)	8/65 (12.3)
Carrying Loaded Backpack between Classes				
Never	25/28 (89.3)	14/29 (48.3)	4/10 (40.0)	3/11 (27.3)
Sometimes	2/28 (7.1)	5/29 (17.2)	4/10 (40.0)	4/11 (36.4)
Often	0/28 (0.00)	5/29 (17.2)	1/10 (10.0)	0/11 (0.00)
All the Time	1/28 (3.6)	5/29 (17.2)	1/10 (10.0)	4/11 (36.4)

[a]Values are expressed as No. (%).

Table 2. Relative Backpack Weight by Demographics and Pain Frequency[a]

	Backpack Weight Relative to Child's Body Weight (RBW)			
	< 10%	**10.1% - 15%**	**15.1% - 20%**	**> 20%**
All Children	38/78 (48.7)	32/78 (41.0)	5/78 (6.4)	3/78 (3.8)
Age, y				
10-12	7/9 (77.8)	2/9 (22.2)	0/9 (0.00)	0/9 (0.00)
13	27/53 (50.9)	21/53 (39.6)	3/53 (5.7)	2/53 (3.8)
14 - 15	4/16 (25.0)	9/16 (56.3)	2/16 (12.5)	1/16 (6.3)
Gender				
Boys	19/40 (47.5)	16/40 (40.0)	6/40 (15.0)	2/40 (5.0)
Girls	19/38 (50.0)	16/38 (42.1)	2/38 (5.3)	1/38 (2.6)
Grade				
6th - 7th grade	10/13 (76.9)	3/13 (23.1)	0/13 (0.00)	0/13 (0.00)
8th grade	28/65 (43.1)	29/65 (38.5)	5/65 (9.2)	3/65 (4.6)
Frequency of Back Pain				
Never	14/28 (50.0)	9/28 (32/1)	3/28 (10.7)	2/28 (7.1)
A few times a month	15/29 (51.7)	12/29 (41.4)	1/29 (3.4)	1/29 (3.4)
A few times a week	5/10 (50.0)	4/10 (40.0)	1/10 (10.0)	0/10 (0.00)
Every day	4/11 (36.4)	7/11 (63.6)	0/11(0.00)	0/11 (0.00)

[a]Values are expressed as No. (%).

Table 3. Contingencies: Frequency of Carrying Loaded Backpack between Classes * Frequency of Back Pain[a]

How often do you carry a loaded backpack between classes?	Frequency of Back Pain [Count (%)]				Total
	Never	A Few Times a Month	A Few Times a Week	Every Day	
Never	25.0 (54.3)	14.0 (30.4)	4.0 (8.7)	3.0 (6.5)	46.0 (100.0)
Sometimes	2.0 (13.3)	5.0 (33.3)	4.0 (26.7)	4.0 (26.7)	15.0 (100.0)
Often	0.0 (0.0)	5.0 (83.3)	1.0 (16.7)	0.0 (0.0)	6.0 (100.0)
All of the Time	1.0 (9.1)	5 (45.5)	1.0 (9.1)	4.0 (36.4)	11.0 (100.0)
Total	28.0 (35.9)	29 (37.2)	10.0 (12.8)	11.0 (14.1)	78.0 (100.0)

[a]Values are expressed as No. (%).

Table 4. Chi-Square Tests: Frequency of Carrying Loaded Backpack between Classes* Frequency of Back Pain

	Value	df	N	P Value
Pearson Chi-Square	26.415	9	78	0.002
Likelihood Ratio	28.049	9	78	0.001

between classes at a rapid pace (a mean of 3.78 minutes for this group), sometimes making locker use impractical and high carrying loads necessary. Adolescents who carry a back pack more frequently throughout the school day were also more likely to report a higher frequency of back pain.

Focused attention to the trend in online textbook distribution was completed to determine if a greater percentage of online textbooks would influence reported frequency of back pain. It was expected that an increased percentage of online texts would yield a reduction in RBW attributable to book weight and thereby decrease the incidence of back pain. Instead, the data suggested an increase in the percentage of online textbooks had no bearing on the incidence of reported back pain frequency.

The results of this study support the notion that there is a prevalence of low back pain in our children. On its own, this finding should create concern amongst parents, educators, and researchers, as presence of childhood back pain has been strongly linked to a lifetime incidence of back pain as adults (4). The focus of most current literature has revolved around RBW, which this study did not support as a cause of back pain. This study did support decreased locker use and increased carrying time of backpacks during the school day as potential causes of back pain. Further, this study failed to demonstrate a link between the use of online text books and reductions in back pain among adolescents.

5.1. Limitations

This study, while ambitious across three collection sites, yielded low subject numbers secondary to the di-

minished return of parental consent forms. Such a small sample size implies that problems associated with lower power should be contemplated when generalizing the results. A survey question collecting the number of minutes students spend either at home or at school on computers/other technology could have further enhanced the analysis and conclusions. Particulars such as child ergonomics, child anthropometrics and posture, load size, shape and body positioning were not examined and could also have yielded insightful information.

5.2. Future Research

Often, online texts have been provided as a solution to offload backpacks for students. As technology increasingly flows into our classrooms, and students rely more often upon technology for learning, care must be taken to avoid substitution of pain from backpacks for pain from poor ergonomics. Hence, attention to posture, proper seating and positioning at computers, along with postural education may direct future research. Additionally, research should be expanded to determine what effect carrying a backpack load has in relation to locker use or physical activity.

5.3. Conclusions

This study concluded that back pain is a common complaint amongst 6th, 7th, and 8th grade students across three different states; however, RBW was not supported as a contributing factor to this back pain. Carrying backpacks between classes may lead to a higher report of back pain; therefore, students should be encouraged to use lockers between classes to decrease the carrying time of loaded backpacks. Lastly, a greater percentage of online to printed textbooks did not decrease back pain; attention to ergonomics is critical, and further research is warranted to determine the significance of and relationships between technology use and back pain.

5.4. Implications for School Health

This research is important to determine ways to ameliorate back pain. Strategies could begin at school and potentially include locker use to store books not necessary for the current class, or improved ergonomics within the classroom with specific attention to posture with computer use. It may prove beneficial to collaborate with school district or local physical therapists to provide educational sessions at the beginning of the school year addressing posture and ergonomics which may spare children from avoidable pain.

5.5. Human Subjects Approval Statement

The study was approved by the university's Institutional Review Board (IRB; 2013.184).

Footnote

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