INTRODUCTION

In recent years, media coverage as well as literature on backpack use in school children has increased around the world. In the United States, reports by CNN, The Wall Street Journal, and Time Magazine, as well as local television stations emulated examining different issues related to backpack use. Typically included in these reports are backpack loads and the assumed relationship with musculoskeletal pain, specifically in the back. Studies, projects, and opinions on backpacks now abound in search engines such as Google. And, while only a handful of research articles on backpacks could be found 2 years ago in PubMed, numerous citations have since emerged in the peer-reviewed medical literature. As a result of often-alarming media reports, concerned parents are demanding change at the local and state levels, ranging from reduced homework to in search engines such as Google. And, while only a handful of research articles on backpacks could be found 2 years ago in PubMed, numerous citations have since emerged in the peer-reviewed medical literature. As a result of often-alarming media reports, concerned parents are demanding change at the local and state levels, ranging from reduced homework to school purchasing a second set of books. While still questioning the link between musculoskeletal pain and backpack use, school officials and legislators have already initiated policy changes.

The current evidence on backpacks and the relationship with musculoskeletal pain is conflicting, and often contrasts with societal perception. Wiersema and colleagues1 documented musculoskeletal pain associated with acute backpack injuries in 247 children presenting to emergency departments. They found that the most common injury mechanisms were tripping, wearing a backpack, and getting hit with a backpack. Surprisingly, 89% of backpack injuries in their study did not involve the back. Goodgold and associates2 surveyed 345 fifth through eighth grade students and found that one third of students complained of back pain. They determined average backpack loads in percentage of body weight (BW) for their sample according to student grade level: 19% BW (5th grade), 21% BW (6th grade), 14% BW (7th grade), and 15% BW (8th grade). Interestingly, they discovered that greater backpack loads did not correlate significantly with the back pain complaints. Negrini and Carabalona3 conducted a cross-sectional study in Italy, weighing backpacks of 237 sixth grade students and surveying 115 students using a validated questionnaire to ascertain the association between backpacks and back pain. Time spent carrying the backpack, as well as subjective perceptions of the backpack causing fatigue, were associated with back pain, but the backpack’s weight was not associated with back pain. These researchers acknowledged the association between backpack loads and back pain, however they concluded that this relationship was not direct. Furthermore, they suggested the existence of personal physical and psychosocial factors that should be investigated in school children. These psychosocial factors included general well-being and self-perception of health.

While examining the proposed link between backpacks and back pain, other investigators reported these psychosocial aspects along with physical findings. Troussier et al4 surveyed 1178 students to investigate the risk factors of back pain in relation to backpack use. These researchers found that the prevalence of back pain in their sample was 51%. Thoracic, lumbar, and leg pain were most commonly reported. Variables that positively correlated with back pain included age, previous back injury, volleyball participation, female gender, and time spent watching television. Harreby and colleagues5 surveyed 1379 thirteen to 16-year-old Danish school students during physical examination by school physicians to determine risk factors for back pain. Physicians measured height and weight, degree of joint hypermobility and tightness of the hamstring muscles, and calculated body mass index (BMI) for each student. Survey questions inquired about sports activity, television watching, computer use, job outside of school, smoking, and multiple aspects of low back pain. Recurrent and continuous low back pain (moderate to severe degree) was reported in 19.4% of children, and was positively correlated with female gender, BMI greater than 25 kg/m², poor physical fitness, smoking, competitive sports for boys, jobs requiring heavy lifting, multiple visits to health care providers, and reduced life quality. Backpack load effects were not reported as risk factors for back pain. Jones and coworkers6 studied 1046 students aged 11 to 14 years at baseline, while also investigating the role of physical and psychosocial factors as risk factors for the onset of low back pain in school children. In children who were initially free of low back pain, they found that psychosocial factors (including behavioral issues) and pre-existing somatic pain complaints were predictive of future low back pain, similar to adult populations. In contrast, they found little evidence to support the link between backpack loads and the onset of low back pain.

Consequently, are current backpack loads really too heavy for school students? Do varying fitness levels in school children, related to current sedentary lifestyles, confound the relationship between musculoskeletal pain and backpack loads? What about the legislation in some states dictating school policy changes? Based on the current evidence available, the relationship between backpack loads and musculoskeletal pain in school children appears to be more complicated than originally assumed.

OUR BACKPACK AWARENESS CAMPAIGN

Using the evidence available and acting at the local level, we currently direct efforts at an elementary/middle school to effect positive changes regarding backpack use within the school environment. As active members of the Regional School Board of Directors at St. Edward-Epiphany School in Richmond, Virginia (the only 2 physical therapists on the board), we assist with policy development and programming to guide our Backpack Awareness Campaign. In addition to keeping up with the available literature on backpacks, local research studies and surveys at this particular school direct our recommendations for change as we develop and refine our comprehensive backpack program on an ongoing basis.

BACKPACK RESEARCH ON A LOCAL LEVEL

As part of our school’s Backpack Awareness Campaign (BAC), we initiated a 3-phase research project 2 years ago to more closely examine multiple issues
related to backpack use. Because of the conflicting evidence available, we believed that our own research would assist us in decision-making on a local level regarding backpack use. Subsequently, results from these studies were presented nationally at the Gait and Clinical Movement Analysis Society 7th Annual Meeting in April 2002 (phases 1 and 2), and at APTA’s Combined Sections Meeting in February 2003 (phase 3).

Phase 1 comprised a formal pilot study conducted at the primary author’s (KW) hospital. We obtained Institutional Review Board (IRB) approval for this study and a small grant. Ten 5th and 6th grade students were randomly selected from our local school and agreed to participate in the study. Plans for the study had been previously introduced to them via a colorful PowerPoint presentation at the school as part of the BAC.

Using computerized motion analysis, a custom 42-marker set was used to collect head, shoulder, and trunk posture and kinematics, in addition to lower extremity kinematics, kinetics, and spatial-temporal parameters. The 6-camera Motion Analysis Corporation system used 120 Hz Hiri™ Falcon cameras strategically positioned on the laboratory walls. With reflective markers in place from head to toe, each student walked on a level walkway carrying 4 different backpack loads (0%, 10%, 15%, and 20% of each student’s body weight). The order of load conditions was randomized for each student at each data collection session to reduce order bias. The same backpack was used for all students. The students walked at a self-selected velocity and cadence, and backpack position was standardized on each student using both straps. Additional data included height, weight, length, backpack style, method of carrying the backpack, scoliosis screening, and frequency and duration of back pain (if experienced). All data were collected in a single session for the 10 students, with 5 students returning a second time to establish test-retest reliability for each load condition.

Phase 2 of the study involved 3rd - 7th grade students at the participating school. The school nurse collected heights and weights on 237 students. We coordinated efforts to weigh backpack loads on a single day (N = 227), and to perform scoliosis screenings for the students whose parents signed consent (N = 59).

Results of Phase 1 and 2 of our studies revealed significant increases in forward head and anterior trunk postures with increasing loads (p < .001), as well as a significant increase in anterior trunk lean during gait in the 20% weight condition (p < .05). These findings coincide with Hong and Cheung’s recent study. No significant changes were found in hip, knee, or ankle kinematics, kinetics, or spatial-temporal gait parameters across conditions. No correlation was found between positive scoliosis screenings and backpack loads. Confirming the suspicion about heavy loads at our school, 38% of all students in grades 3 through 7 carried backpack loads exceeding 20% of body weight. See Table 1 for mean backpack loads according to grade level.

Thus, we demonstrated that our students do carry excessive loads in their backpacks, and that loads exceeding 20% of body weight do cause significant increases in forward head and trunk postures during standing and walking. Goh et al’s® data demonstrating the increased forces acting at the L5/S1 joint with increasingly heavy backpack loads, in addition to our data and the available evidence, reinforced our desire to continue with our approach to BAC. We thought it prudent to address the backpack issue at our school using a variety of preventive and proactive approaches in order to prevent dysfunction in addition to musculoskeletal pain in the student population.

Subsequently, we hypothesized that the etiology of musculoskeletal pain in school children, commonly attributed to heavy backpacks alone, is multifactorial and also relates to the current sedentary lifestyles of adolescents. This hypothesis guided phase 3 of the study, which involved a school-wide survey that we developed and distributed to all school parents. All surveys were anonymous. The surveys included questions on backpack type, pain complaints, physical and sedentary activity reports, availability of cable television and video games at home, fast food consumed per week, and importance of nutrition and diet at home. Findings were reported for 126 students in 3rd - 7th grades. In a different setting, the school nurse collected heights and weights for 198 students in 3rd - 7th grades. Using a customized Excel spreadsheet, body mass indices (BMI) were calculated from the height, weight, age, and gender data for each student according to the National Center for Chronic Disease Prevention and Health Promotion (CDC) growth charts (2000). All BMI data were aggregated according to age and gender. Strict confidentiality was maintained.

Results from Phase 3 revealed that 35 of 126 (28%) students (57% girls, 43% boys) complained of musculoskeletal pain, supposedly caused by their backpacks. Sixth grade students voiced the greatest number of pain complaints, comprising 31% of the total painful students. The most common locations of pain included the back (37% of pain complaints), followed by the neck (18%) and shoulders (18%). Other locations of musculoskeletal pain presumably attributed to backpack use included back and neck areas (9%), shoulders and back (3%), neck and shoulders (3%), headaches (3%), chest area discomfort (3%), leg pain (3%), and hand numbness (3%).

Sixty-five percent of the total number of students surveyed used standard backpacks (using both straps), while 34% of students used rolling backpacks, and 1% used one-shoulder bags. Backpack type distribution in the painful students (N = 35) was no different than the entire student population of 3rd through 7th graders (N = 126). That is, the students complaining of pain did not use standard 1- or 2-strap backpacks more often than rolling backpacks (which are often presumed safer for the spine).

Corresponding with our hypothesis regarding the multifactorial etiology of musculoskeletal pain in school children, we sought to determine the ratio of physical to sedentary activity in these children. For the total number of students surveyed (N = 126), physical activity, defined in our survey as time involved in sports activities in addition to outside play, was performed an average of 2.1 hours per day (median 2.0 hours, SD =

<table>
<thead>
<tr>
<th>Grade</th>
<th>Backpack Load in % Body Weight (BW)</th>
<th>Backpack Weight</th>
<th>Student Weight</th>
<th>% of Students Carrying Backpack Loads ≥ 20% BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd</td>
<td>17%</td>
<td>11 lbs.</td>
<td>65 lbs.</td>
<td>27%</td>
</tr>
<tr>
<td>4th</td>
<td>20%</td>
<td>16 lbs.</td>
<td>82 lbs.</td>
<td>48%</td>
</tr>
<tr>
<td>5th</td>
<td>17%</td>
<td>15 lbs.</td>
<td>92 lbs.</td>
<td>33%</td>
</tr>
<tr>
<td>6th</td>
<td>15%</td>
<td>13 lbs.</td>
<td>94 lbs.</td>
<td>19%</td>
</tr>
<tr>
<td>7th</td>
<td>24%</td>
<td>26 lbs.</td>
<td>111 lbs.</td>
<td>73%</td>
</tr>
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</table>
overweight” in youth is defined as BMI values greater than the 85th percentile. Twenty-four percent of students in 3rd - 7th grades (ages 8–13 years) had BMI values exceeding the 85th percentile, according to the CDC growth charts for gender and age. The male students in our sample comprised a greater proportion of individuals with BMI values exceeding the 85th percentile, compared with the female students. Nine percent of students had BMI values greater than the 95th percentile. According to data from the National Health and Examination Survey (NHANES), the percentage of overweight children was 14% of the US youth population in 1999 (up from 5% twenty years earlier). Due to the anonymity of the surveys, we were unable to correlate BMI values with the subset of painful students.

**Using Our Own Evidence to Guide Change**

Originally developed 5 years ago, the Backpack Awareness Campaign at our local school currently involves not only the school students (preschool through 8th grade), but faculty and parents as well. See Table 2. To date, new activities are planned each school year to increase awareness regarding the proper ways to load, lift, and carry backpacks as well as proper posture. In the past, we have invited different medical professionals from the community to discuss spine-related issues and backpack loads. Disseminating information on a regular basis, we share findings from the current literature with the school community. We coordinate annual backpack weigh-ins, and maintain the data in Microsoft Excel spreadsheets (beginning last year) to track trends over time. Student weights, routinely collected by the school nurse on an annual basis, are used to calculate percentage of body weight (% BW) loads carried in the backpacks. These data regarding backpack loads carried by the students are reported to the faculty, students, and parents at the school in order to encourage positive changes regarding backpack use. We continually encourage all individuals within the school community to brainstorm new ideas to ‘lighten the load.’

Incorporating the current national data on childhood overweight issues in conjunction with our own findings, we emphasized a fitness approach with last year's BAC program. Last year’s school theme was “Backpack Awareness-Focus on Fitness!” which highlighted the fact that physically fit students with strong muscles and good posture are better equipped to carry modern-day backpacks. This theme tied in closely with the Presidential Fitness testing that was initiated last year at the school in the physical education (PE) classes. Pretests were performed at the beginning of the school year by the PE teacher, and scores were compared with end-of-the year post tests. As part of our BAC, we plan to track the fitness levels of students according to grade, age, and gender to help document the effectiveness of our program.

Numerous other activities for the school’s BAC occurred during the campaign’s kick-off week, which coincided with National Backpack Awareness Day last September. These activities included release of results from the school-wide survey of backpack use, which we had conducted the previous spring (phase 3 of our backpack project). To promote school-wide student involvement in the campaign, we also sponsored a poster contest. Consisting of original artwork, all posters illustrated how to properly wear a backpack, how to lighten the backpack load, or how to acquire ‘perfect’ posture. Members of the BAC planning committee awarded prizes to all participants. Additionally, a school-wide assembly, held at the start of the school year for parents and faculty, provided an ideal venue for the distribution of educational materials on backpack use, as well as current backpack facts.

Another activity performed early in the school year included a play entitled...
"Attack of the Backpacks" (written by author KW of this article and her son, a 5th grade student). This innovative play featured up-to-date backpack statistics, proper backpack use, as well as optimal posture and body mechanics in a humorous, fun-filled atmosphere. Fifth grade students, along with teachers from the 3rd - 5th grades, performed this play. The audience consisted of all 3rd - 5th grade students along with their parents who were invited to attend, and the play was videotaped. Appropriate music, consisting of Bill Harley’s Down in the Backpack’ song, added another dimension to the play. We awarded this appropriate music cassette tape as a prize to one young actor. Active participation in the play by school faculty increased awareness of heavy backpack loads, as faculty members present (including the school principal) wore student backpacks at the play’s ending. Our creativity for BAC is limited only by time commitments to our day jobs!

SCOLIOSIS SCREENINGS

When the BAC originated 5 years ago, a link between scoliosis and backpack loads was suspected. Therefore, scoliosis screenings were scheduled annually to coincide with the kick-off week of the campaign. Using a Scoliometer and the advice of a pediatric orthopaedic surgeon, we established a screening program at the school that we now perform on an annual basis. Using parent volunteers who are physical therapists or nurses, we train them to use a cut-off value of 5° on the Scoliometer to distinguish a positive screen. After each school student was screened, American Physical Therapy Association (APTA) brochures on scoliosis were distributed for the students along with their parents who were invited to attend, and the play was videotaped. Appropriate music, consisting of Bill Harley’s Down in the Backpack’ song, added another dimension to the play. We awarded this appropriate music cassette tape as a prize to one young actor. Active participation in the play by school faculty increased awareness of heavy backpack loads, as faculty members present (including the school principal) wore student backpacks at the play’s ending. Our creativity for BAC is limited only by time commitments to our day jobs!

Interestingly, we became involved in scoliosis screenings when the school nurse requested our assistance with the scoliosis screening program. Even though a direct link between scoliosis and backpack loads has not been established to date, the screening program heightens awareness of posture and is well received by the parents of the school students, as reported on our survey instrument for school families. Therefore, we continue to manage the scoliosis screening program at the school, and we conduct the screenings as part of the comprehensive BAC.

CONCLUSIONS

The current dilemma regarding backpacks and the relationship with musculoskeletal pain in school children appears related to multiple factors, which we are addressing through our programs. We plan to continue our Backpack Awareness Campaign, including annual data collection to monitor backpack loads, while educating students, parents, and faculty to ensure proper packing, lifting, and carrying of backpacks. Last spring, based on the findings from our backpack studies, our school board voted in favor of purchasing a second set of textbooks, to be kept at home, for grades 4 through 7. We are also currently investigating the possibility of obtaining textbooks on CD-ROM for student use.

In conjunction with the PE teacher at this school, we plan to monitor fitness levels of students and track them on an annual basis. We will explore additional ways to encourage fitness and physical activity within the school community.

In addition to attention directed at backpack loads and the methods of lifting and carrying backpacks, lifestyle habits of school students will also be addressed at the school. Increasing the ratio of physical to sedentary activity, along with improving fitness levels in students, may assist in not only reducing musculoskeletal pain in school children, but also in optimizing health. As a spin-off from our studies at the school, in conjunction with the data on the current obesity epidemic in the United States, we have implemented a Healthy Families Initiative to encourage enhanced opportunities for physical activity as well as healthy eating habits for the school students and their families. Acknowledging the Surgeon General’s Call to Action To Prevent and Decrease Overweight and Obesity 2001, we continue to propose policies and subsequently implement new ways to improve lifestyle habits in an effort to combat this public health epidemic. As this article goes to press, we are proactively responding to this Call to Action and exploring opportunities for the implementation of our Healthy Families Initiative, in addition to our involvement with BAC at the local level.

REFERENCES


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