ChiroACCESS Article

Children, Backpacks and Back Pain

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ChiroACCESS Editorial Staff
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Over a third of the children in the United States have back pain they associate with wearing backpacks. Recently several studies were published that provide a better picture of the risks associated with the ergonomic loading of backpacks. From this research there is additional information that each chiropractor should be aware of in order to prevent unnecessary backpack related injuries to children.

One 2010 study used standing magnetic resonance imaging to examine the biomechanical loading of children wearing backpacks. The study was the first to quantify the decrease in lumber disc height and curvature associated with backpacks. "Backpack loads are responsible for a significant amount of back pain in children, which in part, may be due to changes in lumbar disc height or curvature." Other studies reflect changes in gait. One study found that "Backpack load carriage increases ground reaction forces and increases the stiffness in the upper extremity that can cause transmission of higher amount of forces from the lower extremity to the head." This finding might be associated with both cervical symptoms and headache.

Doctors should consider advising parents and children to limit backpack weight. The accepted range has been 10-15% of the child's bodyweight; but one of the more recent studies makes a case for restricting the weight to no more than 10% of bodyweight. There is also a need to consider how the backpack weight is distributed. As one study reported, "Anteriorly carried backpack with centre of gravity positioned at T12 was shown to induce relatively less effect on spinal deformation and repositioning error in schoolchildren. Changing backpack carriage position occasionally may help to relieve its effects on spinal deformation."

The effect of backpacks on the lumbar spine in children: a standing magnetic resonance imaging study.

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STUDY DESIGN: This study is a repeated measures design to measure the lumbar spine response to typical school backpack loads in healthy children. The lumbar spine in this setting was measured for the first time by an upright magnetic resonance imaging (MRI) scanner.

OBJECTIVE: The purpose of this study is to measure the lumbar spine response to typical school backpack loads in healthy children. We hypothesize that backpack loads significantly increase disc compression and lumbar curvature.

SUMMARY OF BACKGROUND DATA: Children commonly carry school backpacks of 10% to 22% bodyweight. Despite growing concern among parents about safety, there are no imaging studies which describe the effect of backpack loads on the spine in children.

METHODS: Three boys and 5 girls, age 11 +/- 2 years (mean +/- SD) underwent T2 weighted sagittal and coronal MRI scans of the lumbar spine while standing. Scans were repeated with 4, 8, and 12 kg backpack loads, which represented approximately 10%, 20%, and 30% body weight for our sample. Main outcome measures were disc compression, defined as post- minus preloading disc height, and lumbar asymmetry, defined as the coronal Cobb angle between the superior endplates of S1 and L1.

RESULTS: Increasing backpack loads significantly compressed lumbar disc heights measured in the midline sagittal plane ($P < 0.05$, repeated-measures analysis of variance [ANOVA]). Lumbar asymmetry was: 2.23 degrees +/- 1.07 degrees standing, 5.46 degrees +/- 2.50 degrees with 4 kg, 9.18 degrees +/- 2.25 degrees with 8 kg, and 5.68 degrees +/- 1.76 degrees with 12 kg (mean +/- SE). Backpack loads significantly increased lumbar asymmetry ($P < 0.03$, one-way ANOVA). Four of the 8 subjects had Cobb angles greater than 10 degrees during 8-kg backpack loads. Using a visual-analogue scale to rate their pain (0-no pain, 10-worst pain imaginable), subjects reported significant increases in back pain associated with backpack loads of 4, 8, and 12 kg ($P < 0.001$, 1-way ANOVA).

CONCLUSION: Backpack loads are responsible for a significant amount of back pain in children, which in part, may be due to changes in lumbar disc height or curvature. This is the first upright MRI study to document reduced disc height and greater lumbar asymmetry for common backpack loads in children.

Short-term effects of backpack load placement on spine deformation and repositioning error in schoolchildren.

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Backpack weight of 10-15% has been recommended as an acceptable limit for schoolchildren. However, there is still no clear guideline regarding where the backpack centre of gravity (CG) should be positioned. The changes of spinal curvature and repositioning error when carrying a backpack loaded at 15% of body weight at different CG locations (anterior or posterior at T7, T12 or L3) in schoolchildren were analysed. Both spinal curvature and repositioning error were found to be affected by backpack anterior-posterior position and CG level. A relatively smaller change was observed during anterior carriage with the least change when the backpack CG was positioned at T12. The results also suggested that alternative carriage by changing the backpack position occasionally between anterior and posterior positions might help to relieve the effects of backpack on spine. However, future study is recommended to further substantiate the beneficial effects of alternative carriage on children.

STATEMENT OF RELEVANCE: Anteriorly carried backpack with centre of gravity positioned at T12 was shown to induce relatively less effect on spinal deformation and repositioning error in schoolchildren. Changing backpack carriage position occasionally may help to relieve its effects on spinal deformation. The findings are important for ergonomic schoolbag design and determining a proper load carriage method.

Effect of Backpack Weight on Postural Angles in Preadolescent Children.

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Background: Carrying heavy backpacks could cause a wide spectrum of pain related musculoskeletal disorders and postural dysfunctions. Objective: To determine the changes in various postural angles with different backpack weights in preadolescent children. Design: Cross-sectional. Participants: Healthy male school-children (n=200), mean (SD) age: 12.5 (0.5) years, from high schools in Mangalore, India. Measurements: Bodyweight and height were measured using a forceplate and stadiometer, respectively. From the weight recorded, 5%, 10%, 15%, 20%, and 25% of the bodyweight were calculated and implemented as their respective backpack loads. The Image Tool version 3.0, digitizing **software** was used for analyzing photographs to determine craniovertebral (CV), head on neck (HON), head and neck on trunk (HNOT), trunk and lower limb angles. Postural angles were compared with no backpack and with backpacks weighing 5% to 25% of the subjects bodyweight. Results: The CV angle changed significantly after 15% of backpack load ($P < 0.05$). The HON and HNOT angles changed significantly after 10% of backpack load ($P < 0.05$). The trunk and lower limb angle also changed significantly after 5%; of backpack load ($P < 0.05$). Conclusions: Carrying a backpack weighing 15% of body weight change all the postural angles in preadolescent children.

Effects of backpack carriage on gait parameters in children.

Pediatr Phys Ther. 2008 Winter;20(4):347-55.

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PURPOSE: Carrying a backpack over 2 shoulders is the most efficient means of carriage, but often backpacks are carried over 1 shoulder. Our purpose was to assess walking base of support, stride length, double support time, and velocity when backpacks were carried on 1 or 2 shoulders.

METHODS: Thirty-two children (12-13 years) were assessed under 2 load conditions using the GAITRite system.

RESULTS: No significant differences were found in base of support, stride length, or velocity when compared with the unloaded baseline walk. Double limb support significantly increased ($p < 0.0001$) with both load conditions when compared with the baseline, but not between 1-shoulder and 2-shoulders carriage.

CONCLUSION: Little change in temporal-spatial gait parameters was noted during backpack use with loads limited to 15% body weight. Future studies need to examine the effects of the child's height, body mass index, and strength on safe backpack use.

Thoracic spine pain in the general population: prevalence, incidence and associated factors in children, adolescents and adults. A systematic review.

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BACKGROUND: Thoracic spine pain (TSP) is experienced across the lifespan by healthy individuals and is a common presentation in primary healthcare clinical practice. However, the epidemiological characteristics of TSP are not well documented compared to neck and low back pain. A rigorous evaluation of the prevalence, incidence, correlates and risk factors needs to be undertaken in order for epidemiologic data to be meaningfully used to develop evidence-based prevention and treatment recommendations for TSP.

METHODS: A systematic review method was followed to report the evidence describing prevalence, incidence, associated factors and risk factors for TSP among the general population. Nine electronic databases were systematically searched to identify studies that reported either prevalence, incidence, associated factors (cross-sectional study) or risk factors (prospective study) for TSP in healthy children, adolescents or adults. Studies were evaluated for level of evidence and method quality.

RESULTS: Of the 1389 studies identified in the literature, 33 met the inclusion criteria for this systematic review. The mean (SD) quality score (out of 15) for the included studies was 10.5 (2.0). TSP prevalence data ranged from 4.0-72.0% (point), 0.5-51.4% (7-day), 1.4-34.8% (1-month), 4.8-7.0% (3-month), 3.5-34.8% (1-year) and 15.6-19.5% (lifetime). TSP prevalence varied according to the operational definition of TSP. Prevalence for any TSP ranged from 0.5-23.0%, 15.8-34.8%, 15.0-27.5% and 12.0-31.2% for 7-day, 1-month, 1-year and lifetime periods, respectively. TSP associated with backpack use varied from 6.0-72.0% and 22.9-51.4% for point and 7-day periods, respectively. TSP interfering with school or leisure ranged from 3.5-9.7% for 1-year prevalence. Generally, studies reported a higher prevalence for TSP in child and adolescent populations, and particularly for females. The 1 month, 6 month, 1 year and 25 year incidences were 0-0.9%, 10.3%, 3.8-35.3% and 9.8% respectively. TSP was significantly associated with: concurrent musculoskeletal pain; growth and physical; lifestyle and social; backpack; postural; psychological; and environmental factors. Risk factors identified for TSP in adolescents included age (being older) and poorer mental health.

CONCLUSION: TSP is a common condition in the general population. While there is some evidence for biopsychosocial associations it is limited and further prospectively designed research is required to inform prevention and management strategies.

Effect of backpack load placement on posture and spinal curvature in prepubescent children.

Work. 2009;32(3):351-60.

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Parents, educators and researchers have expressed concern about the long term impacts of children carrying excessive loads in their backpacks on a daily basis. Although many researchers have investigated appropriate weight limits for children's packs, little research has been conducted on the design of children's backpacks. The purpose of this study was to evaluate the changes in children's trunk forward lean (TFL), cranio-vertebral angle (CVA) and spinal lordosis angle (LA) that occurred with high, medium and low load locations during standing and walking. Ten-year-old children (n = 15) completed a repeated measures designed study while carrying 15% of each child's body weight in a typical backpack with only shoulder straps. A special instrumented backpack (IBP) was designed that allowed the weight to be placed in the proper location and continuously measure changes in spinal curvature. TFL and CVA postures were captured on digital video at five intervals including: standing without a backpack prior to a 1000 m walk; standing with a backpack at the beginning and end of a 1000 m walk; and walking with a backpack at the beginning and end of a 1000 m walk. Results indicated that significant changes occurred in TFL and CVA when the backpack was loaded to 15% body weight. The low load placement in the backpack produced fewer changes in CVA from the initial standing baseline measure than the high and mid placements. When all measures were assessed collectively, there were fewer changes in LA in the low load placement. These findings indicate that future backpack designs should place loads lower on the spine in order to minimize

children's postural adaptations.

Backpack load limit recommendation for middle school students based on physiological and psychophysical measurements.

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The load of student's backpacks has raised questions over the safety and health of schoolchildren everywhere. The purpose of this study is to use electromyography (EMG), posture evaluation, heart rate, and ratings of perceived exertion and perceptions of pain to find an acceptable backpack load limit for middle school students. Twenty middle school students aged 11 to 14 (10 female and 10 male) volunteered for the study. The subjects completed two tests, standing stationary and walking on a treadmill, where they carried 5% incremental loads from 0% body mass (BM) to 20% BM. The study indicated that the Borg-CR10 ratings and trunk flexion angle for the walking trial indicated a possible load limit of 10% BM due to the non-significant difference between 0 and 10% BM and the significant difference between 10 and 15% BM.

Lower limb dynamics change for children while walking with backpack loads to modulate shock transmission to the head.

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Backpack load carriage increases ground reaction forces and increases the stiffness in the upper extremity that can cause transmission of higher amount of forces from the lower extremity to the head. This study investigated the effect of load carriage and placement of load on the back on the shock transmission mechanisms amongst children. Fifteen primary school boys with mean age 10.01 (+/-1.31) years, mean height 136.40 (+/-10.08)cm and mean mass 31.83 (+/-7.13)kg completed the study. Subjects carried 10%, 15% and 20% bodyweight (BW) loads on two locations on the back, namely upper and lower. Results showed a significant reduction in pelvic and trunk rotation in the transverse plane and an increase in the upper body stiffness for loads exceeding 15% of BW. The lower limb results showed a reduction in the first peak force and cadence and a significant change in the walking velocity and time to the first peak force for 20% load. No significant differences were found for the load configuration but the upper configuration showed slightly higher shock transmission. The changes in the lower limb dynamics indicated that there are locomotion mechanisms in place amongst children to modulate shock transmission to the head.