The Effects of Backpack Use on Posture and Gait in School-Age Children – A Pilot Study

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Introduction

Back pain has been identified as a significant public health problem in adults, and more recently in children and adolescents. With increasing scrutiny on backpack loads, recommendations not to exceed 10% - 20% of a student's body weight are commonly reported by health professionals and the media. However, which guidelines to follow and the reasons underlying the guidelines remain unclear. The purpose of this pilot study was to define how increasingly heavier backpack loads affect posture and gait in school -age children, as well as to ascertain specific backpack loads at a participating local school.

Methodology

Phase 1 for N = 10

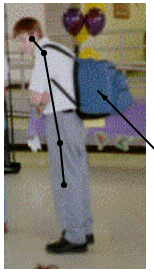
- 10 healthy students (5 girls, 5 boys) in 5th – 6th grades
- 5 tested twice to establish test-retest reliability for each condition
- Custom 42-marker set
  - Head, shoulder & trunk posture and kinematics
  - Lower extremity kinematics, kinetics, spatial-temporal parameters
- 6-camera Motion Analysis 120 Hz HiRes system
- Level walking with **4 different backpack loads**
  - **0%, 10%, 15%, 20%** of each subject's body weight (BW)
- Self-selected velocity and cadence
- Random order of conditions
- Backpack position standardized on each subject w/ both straps
- Other data:
  - Height, Weight, Leg lengths, Backpack style, Scoliosis screen, Frequency of back pain, Duration of back pain

Phase 2 for N = 227

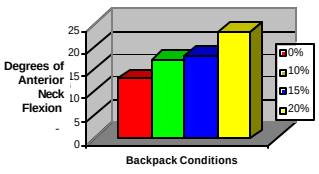
- Height & weight for 3rd – 7th grade students at participating school
- Backpack loads on a single day for all 3rd – 7th graders
- Scoliosis screenings (N = 59)

Results

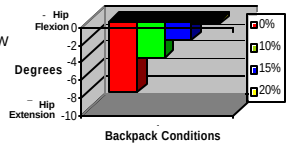
Static Load Effects



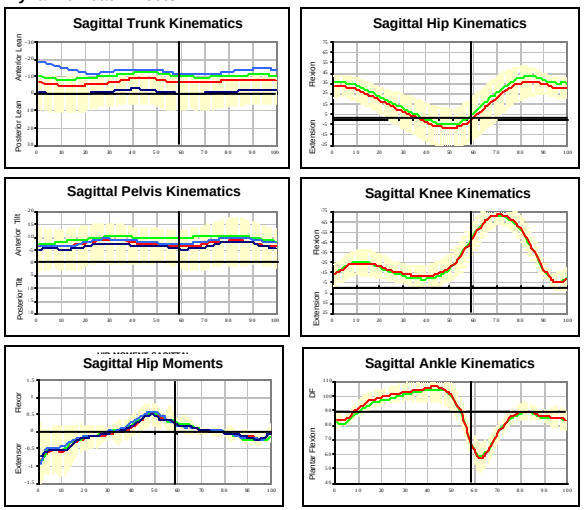
Forward Head Posture



Sagittal Trunk Posture - Hip Angle



Dynamic Load Effects



20% Blue Curve, 15% Green Curve, 10% Red Curve, 0% Black Curve
Yellow band: ± 2 SD for 0% condition (N = 10)

Day 1 Red Curve, Day 2 Green Curve,
Yellow band: ± 2 SD for Day 1
Test-Retest Reliability for 20% condition (N = 5)

- √ Significant increase in forward head posture with increasing loads ($p < .001$)
- √ Significant increase in anterior trunk posture with increasing loads ($p < .001$)
- √ Significant increase in anterior trunk lean during gait in the 20% condition ($p < .05$)
- √ No significant changes in hip, knee or ankle kinematics, kinetics nor spatial-temporal parameters across conditions
- √ No correlation between positive scoliosis screenings and backpack loads
- √ Test-retest repeatability acceptable for 5 subjects on 2 days across conditions

Sagittal Postural Angles & Spatial-Temporal Parameters

(Mean values for N = 10)	0%	10%	15%	20%	p value *
Forward Head Posture (°)	13	17	18	24	<.001
Anterior Trunk Lean (°)	-8	-4	-2	0	<.001
Double Limb Support (%)	15	16	17	18	N.S.
Single Limb Support (%)	43	42	42	41	N.S.
Cadence (steps/min)	124	121	123	120	N.S.
Velocity (m/sec)	1.1	1.1	1.1	1.0	N.S.
Step Length (m)	.07	0.7	0.6	0.7	N.S.
Stance (%)	58	57	58	59	N.S.

* Repeated Measures ANOVA, N.S. = not significant

Mean Loads for N = 227

Grade	% Body Weight	Backpack Mass (Weight)	Student Mass (Weight)
3rd	17%	5 kg (11 lbs.)	30 kg (65 lbs.)
4th	20%	7 kg (16 lbs.)	37 kg (82 lbs.)
5th	17%	7 kg (15 lbs.)	42 kg (92 lbs.)
6th	15%	6 kg (13 lbs.)	42 kg (94 lbs.)
7th	24%	12 kg (26 lbs.)	50 kg (111 lbs.)

Backpack Load Carriage ³ 20% BW (N = 227)

Grade	Number of Students	Percentage of Students
3rd	13	27%
4th	22	48%
5th	16	33%
6th	9	19%
7th	27	73%

Discussion

Forward head posture and sagittal trunk alignment in standing, as well as anterior trunk lean kinematics, were the only variables significantly affected by increasing backpack loads. Significant increases in anterior pelvic tilt kinematics as well as hip extensor moments were anticipated, but not found. Consequently, we suspect increased muscular effort and stress within the cervical, thoracic and lumbar spine due to the anteri or orientation of the trunk relative to the pelvis with heavy backpack loads. However, to evaluate this hypothesis, biomechanical modeling of spinal structures extending from the occiput to the sacrum may be necessary to discern the relationships between backpack loads and adolescent back/neck pain.

Use of percentage body weight as the sole guideline for safe backpack loads does not take into account different body types, nor fitness levels. And, the fact remains that children and adolescents will continue to carry the books necessary for their particular grade level. Thus, thin lighter children may be at a greater risk than their heavier peers, since the lighter children will tend to carry proportionally heavier loads. Furthermore, present guidelines indicate that greater loads may be safely carried by heavier children, who may in fact, be less physically fit. The "bigger picture" of the links between increasingly sedentary lifestyles in adolescents with decreased fitness levels, adolescent back pain, and backpack loads may warrant investigation.

Acknowledgements

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