The Effects of Backpack Placement on Upper Body Forward Postural Angles: Craniovertebral, Sagittal Shoulder, and Trunk Forward Lean

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Abstract. This study examined effects of backpack placement on posture while walking when backpacks are worn with two shoulder straps at two different heights. Thirty young, healthy adults underwent motion analysis to capture posture using an identified marker set to observe three angles used to measure posture with the backpack worn at high and low spinal levels. High and low backpack placement resulted in differences in upper body postural angles. These results suggest that backpack placement has an impact on forward posture, however functional postural change could not be determined.

1. Introduction

Incorrect backpack placement can lead to changes in craniovertebral angle (CVA), sagittal shoulder angle (SSA), and trunk forward lean (TFL). Backpack weight greater than 17% of body weight can lead to poor posture causing muscle imbalances, pain and dysfunction [1]. Further exploration of backpack of loads at the seventh cervical and thoracic levels (C7 and T7) is needed to determine whether differences exist in postures mentioned above. The purpose of this study was to determine if backpack placement loaded to 17% body weight at C7 and T7 affects posture.

2. Experiment, Results, Discussion, and Significance

Methods

Subjects
Thirty-four participants (18-30 years of age) were tested. Exclusions included neck, back, or shoulder surgeries within the last 12 months, current neck, back or shoulder pain or pregnancy. All participants gave written informed consent.

Instrumentation
The Owl Digital RealTime System uses Owl Digital cameras and MotionAnalysis Cortex software to accurately record and calibrate motions in real-time. Calibration was completed prior to data collection, and recalibrated periodically.

Procedures
Participant-selected walking speed was calculated as the average of three 10 meter timed walks. Participant’s weight determined backpack load. Markers (n=29) were applied following the modified Helen Hayes marker set. Two markers were placed on floor in front of and behind the treadmill to form a horizontal line to complete SSA and TFL. Participants donned unweighted backpack and assumed “T” pose to fit the marker template in MotionAnalysis Cortex. Once the marker set was recognized, participants hooked thumbs into the backpack straps and looked straight ahead. Participants straddled the treadmill until it reached the pre-calculated speed. Once participants mounted the treadmill, data collection occurred at three 10 second intervals, with rest periods following each trial. After baseline trial, the backpack was loaded with 17% of bodyweight and placed at appropriate randomized level (C7 and T7).

Data Analysis
MotionAnalysis Cortex software extrapolated CVA, SSA, and TFL.

Statistical Analysis
A repeated measures analysis of variance with Bonferroni’s correction was used for analysis (SPSS V19). The alpha level was set at 0.05.
Results
Mean outcomes for backpack placement at baseline, T7, and C7 are shown in the Table.

<table>
<thead>
<tr>
<th>Backpack Placement</th>
<th>Cervical Vertebra Angle (degrees)</th>
<th>Sagittal Shoulder Angle (degrees)</th>
<th>Trunk Forward Lean Angle (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>44.56° [49-55]</td>
<td>110.47° c</td>
<td>8.48° e</td>
</tr>
<tr>
<td>Low (T7)</td>
<td>42.96° [49-55]</td>
<td>107.50° a</td>
<td>7.89° d</td>
</tr>
<tr>
<td>High (C7)</td>
<td>43.65 ° [49-55]</td>
<td>106.68° d</td>
<td>7.89° d</td>
</tr>
</tbody>
</table>

* Matching letters denote significant difference < 0.05 with Bonferroni’s correction

Discussion
There was a significant difference in CVA, SSA, and TFL between backpack placement at C7 and T7. An overall decrease occurred in CVA compared to normal individuals, which implies a more pronounced forward head posture. Negative effects lead to possible headaches, neck pain, temporomandibular disorders, vertebral body disorders, soft tissue length and strength alteration, or scapula and shoulder dyskinesis [3]. Excessive forward shoulder posture has been recognized as a factor contributing to head, shoulder, and neck pain [4]. Although further research is needed to determine TFL in normal individuals, Negrini found normal TFL to be 12 mm anterior to a plumb line [5]. Decreased TFL increases anterior strain on skeletal musculature [6]. Lower load placement produces more forward body lean, adding weight to the front half of the feet [7]. Three limitations were noted: 1) the horizontal line making up one vector of SSA from a line between C7 and the greater tuberosity had to be changed for technical reasons; 2) level of the backpack during the baseline trial was not kept constant. Instead of a consistent backpack height, the level for the baseline trial was determined by the assigned level of the participant’s first data collection trial; 3) participant hooked the thumbs into the backpack straps to avoid marker obstruction, eliminating natural arm swing. Further research is needed to identify the amount of deviation from average postural angles which would cause functional deficits.

3. Conclusions
The results suggest that backpack placement in normal healthy, young adults has an impact on forward posture, however, functional postural change is unable to be determined.

4. Acknowledgements
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5. References


