EFFECTS OF OBESITY ON SYMMETRY AND SPATIO-TEMPORAL CHARACTERISTICS OF ADOLESCENT GAIT

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INTRODUCTION

Child obesity is becoming all too prevalent as society becomes more sedentary. The percentage of overweight children 12-19 yrs old in the U.S. has increased over 11% since 1980, with the current level reported at 16.1% [1]. In adults, gait characteristics have been shown to vary with increasing adiposity, most notably a slower preferred walking speed, longer stance and double support phases, and greater base of support [2-4]. It is not known if obesity leads to similar locomotor outcomes for adolescents. In addition, the question of symmetry has been raised relative to limb dominance observed in obese children [5]. The purpose of the study was to examine the effects of obesity on bilateral symmetry and spatio-temporal characteristics of adolescent walking.

METHODS

Institutionally approved written parental permission and child assent was obtained from 111 adolescents between the ages of 12 to 17 years of age (14.2 ± 1.4 yrs) enrolled in grades 7-10 at a charter school. All participants performed walking trials as part of a regularly scheduled physical activity period during the school day. The height and weight of each participant was obtained by a registered nurse using a digital medical beam scale (HealthOMeter, 500 KL).

Each participant walked twice at their preferred pace over a 4.27 m instrumented walkway (CIR Systems, Haverhill, PA; 120 Hz), which was centered in a 10 m hallway and placed directly over the carpet-over-concrete flooring. All participants started at the same position, walked through the hallway and over the walkway, stopped, turned around, and walked back to the starting position. Next, each participant was given the verbal instruction: “Walk as fast as you can” in order to elicit a fast walking condition. Approximately two walking strides were completed prior to and following contact with the walkway. There was no attempt to control for footwear or attire that the participants wore during data collection, thus replicating typical school day locomotion for each participant.

Body mass index (BMI) was calculated for each participant following procedures established by the Centers for Disease Control for children and teens. This procedure to determine adiposity level is both age and gender specific and scales the BMI value to age and gender percentile values. All participants with BMI% <85th percentile were assigned to the normal weight (NW) group (n = 70) while those with BMI% ≥85th percentile were assigned to the overweight/obese (OWO) group (n = 41).

The two passes over the walkway at each speed were concatenated producing 8-17 complete walking steps per participant-speed. Six spatio-temporal dependent variables (velocity, Vel; cadence, Cad; step length, SL; percent swing, SW; percent double support, DS; stance width, StWd) and three right-left difference symmetry dependent variables (step time, step length, cycle time) were extracted using custom software (GAITRite, version 4.0, 59). Vel and SL were normalized to leg length.

Two-way mixed model Group x Speed analyses of variance were used to address the study purpose. Level of significance was set at α = 0.05. The right-left symmetry analysis was conducted first in order to determine whether there was a need to separate limbs for subsequent analyses. All statistical tests were conducted using SAS (version 9.1) software.
RESULTS AND DISCUSSION

The symmetry analysis resulted in no significant interactions or right-left limb differences (symmetry) in step time, step length or cycle time by group or speed (p > 0.05), therefore, data for only one limb was used to assess the spatio-temporal parameters. There were no significant Group x Speed interactions observed for any of the spatio-temporal parameters. With the exception of StWd, all dependent variables were significantly different (p < 0.05) for levels of speed. Vel, Cad, SW, DS and StWd were all significantly different (p < 0.05) between the NW and OWO groups. Results are summarized in Table 1.

Hills [5] previously commented on the observation of limb asymmetry in children as a result of obesity, but did not specify the age range of the referenced children. Subsequently, Hills et al, [6] reported limb asymmetry in pre-pubescent obese children. In contrast, the current study failed to detect significant limb differences in step length, step time or cycle time at levels of speed or group. It may be that our subjects were older than those in Hills et al [6] and it is not clear if symmetry is a function of skillful locomotion as opposed to adiposity per se.

Differences observed between preferred and fast walking were anticipated per study design. Our interest in incorporating walking speed as a factor in the design was to specifically examine any potential interaction effects between group and speed, which were not found. One can conclude that NW and OWO adolescents achieve a faster walking speed by scaling on similar parameters, none of which influence StWd. The observed increases in StWd and DS for OWO may be the result of optimizing on stability while decreased SW could be the combined result of stability and lack of core strength to control the inertial characteristics of the swing leg, therefore spending more time in the stance phase of gait.

CONCLUSIONS

Obesity was not shown to influence bilateral gait symmetry in adolescents. Locomotor differences observed between NW and OWO adolescents were similar to those reported for similarly grouped adults [2-4]. Further research is needed to determine whether such differences in walking patterns precipitating at an early age place OWO adolescents at greater risk earlier in their lives for joint pain or debilitating joint degeneration.

REFERENCES


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Table 1: Main effect mean and standard deviation values by variable.

<table>
<thead>
<tr>
<th>Main Effect</th>
<th>Level</th>
<th>Vel (m/s)</th>
<th>Cad (Hz)</th>
<th>SL (m)</th>
<th>SW (% cycle)</th>
<th>DS (% cycle)</th>
<th>StWd (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>NW</td>
<td>1.51 ± 0.3</td>
<td>116.5 ± 14.1</td>
<td>0.77 ± 0.09</td>
<td>38.8 ± 2.0</td>
<td>22.5 ± 3.9</td>
<td>0.09 ± 0.03</td>
</tr>
<tr>
<td></td>
<td>OWO</td>
<td>1.44 ± 0.3</td>
<td>113.6 ± 12.8</td>
<td>0.75 ± 0.09</td>
<td>36.9 ± 2.3</td>
<td>26.3 ± 4.0</td>
<td>0.10 ± 0.03</td>
</tr>
<tr>
<td>Speed</td>
<td>Preferred</td>
<td>1.28 ± 0.2</td>
<td>107.6 ± 10.0</td>
<td>0.71 ± 0.07</td>
<td>37.2 ± 2.1</td>
<td>25.7 ± 4.0</td>
<td>0.09 ± 0.04</td>
</tr>
<tr>
<td></td>
<td>Fast</td>
<td>1.70 ± 0.3</td>
<td>123.5 ± 12.1</td>
<td>0.82 ± 0.08</td>
<td>38.9 ± 2.2</td>
<td>22.2 ± 4.0</td>
<td>0.09 ± 0.04</td>
</tr>
</tbody>
</table>

Italics represents significant (p < 0.05) difference.