10-meter walking test among obese and non-obese community dwelling elderly
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Abstract: There are over 72 million people in the US are obese (BMI>30). Falls have been identified as the most common cause of injuries in the obese, and obese elderly fell almost twice as frequently as their lean counterparts per year. Falls among older adults often occur during walking, and gait dysfunction is included among the many risk factors for falls. As such, this study evaluated gait functions during 10-meter walking tasks among twenty community-dwelling elderly. Ten obese elderly and ten non-obese elderly (aged 65-84) participated in this study. Participants were asked to walk at self-selected pace for two 10-meter trials. This was performed on a walking course marked by blue tape on the floor to indicate 10-meter distance. Total walking time was recorded. Three custom-made wireless inertial measurement units (IMUs) were attached on participants’ trunk and both shanks to obtain the temporal and kinematic parameters. The results showed that there was no significant difference in walking velocity, stance time, double support time, step length, cadence and total walking time to complete the task (p>0.05) between the obese and non-obese groups. However, obese participants walked with significantly less swing time than their non-obese counterparts (p=0.04). The less swing time may be explained as gait adaptations among the obese related to their increased need of effort to move a heavier limb with impaired lower extremity muscle functions. However, the evaluation of walking behavior itself would not provide sufficient information to identify differences in the dynamic postural control between obese and non-obese elderly.

Keywords: Falls, obese, community-dwelling elderly, Inertial Measurement Units

1. Introduction

The World Health Organization estimates that in 2008, more than 1.4 billion adults are obese (WHO, 2013). In the US, there are over 72 million people who are obese (Ogden et al., 2007). The latest figures from the Centers for Disease Control and Prevention (CDC) also indicated that obesity is a significant public health problem in the United States. Obesity is often associated with structural and functional limitations that may limit movement control (Hills et al., 2002). One of the many concerns is its association with an increased risk of falls and subsequent injuries. Falls have been identified as the most common (36%) cause of injuries in the obese (Matter et al., 2007), and obese elderly fell almost twice as frequently (27%) as their lean counterparts (15%) per year (Fjeldstad et al., 2008). Although epidemiological studies clearly indicated the increased risk of falls in the obese elderly, the mechanisms associated with this increased fall risk among obese elderly (Wu et al., 2012) are still unknown.

Obesity is a known risk factor for several diseases (WHO, 2000), and negatively affects physical functioning, especially walking ability and performance (Houston et al., 2009; Stenholm et al., 2007). Studies have shown that walking ability is an important predictor factor for falls in the elderly (Hausdorff et al., 2001). Thus, understanding the mechanisms that may affect the ability to walk in obese older individuals may help identifying target for fall prevention and intervention. Therefore, the objective of this study was to study the gait characteristics between obese and non-obese elderly using a clinically validated gait assessment tool (i.e. 10 meter walking test) (Scivoletto et al., 2011). We hypothesized that obesity as quantified by Body Mass Index (BMI) would influence their gait characteristics leading to higher risk of falls.
2. Method

2.1 Participants

Twenty community-dwelling elderly (aged 65-84, ten non-obese and ten obese) participated in this study. Among the twenty participants, there are six obese females, four obese males and four non-obese females, six non-obese males. Informed consents were obtained from the participants before the experiment (Virginia Tech IRB approved). Participants with walking aid were excluded from this study. Participants’ anthropometric data is presented in Table 1.

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>Weight (kg)</th>
<th>Height (m)</th>
<th>BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-obese</td>
<td>75.4±3.4</td>
<td>72.5±8.7</td>
<td>1.63±0.10</td>
<td>25.7±3.08</td>
</tr>
<tr>
<td>Obese</td>
<td>76.3±4.5</td>
<td>108.8±16.2</td>
<td>1.64±0.11</td>
<td>36.9±7.02</td>
</tr>
</tbody>
</table>

2.2 Equipment

Three custom-made wireless inertial measurement units (IMUs) (TEMPO, Figure 1) were attached on participants’ sternum and both ankles (lateral sides) to obtain the temporal and kinematic data. TEMPO: Technology-Enabled Medical Precision Observation, was manufactured in collaboration with the inertia team from University of Virginia. The TEMPO system consists of MMA7261QT tri-axial accelerometers and IDG-300 (x and y plane) and ADXRS300A (z plane) uniaxial gyroscopes. These sensors capture three axes of both linear acceleration and angular rate at 128 Hz, providing six degrees of freedom motion capture in the form factor of a wristwatch (Barth et al., 2009). The data acquisition was carried out using a Bluetooth adapter and laptop via a custom-made LabView VI (Barth et al., 2009). Stopwatch was also used to time the 10-meter walking completion time.

2.3 Experiment protocol

Wearing their own footwear, participants were asked to walk at self-selected pace for two trials. This was performed on a walking course marked by blue tape on the floor to indicate 10-meter distance. Total walking time of each trial was recorded.

2.4 Analysis

The mean of the two timed trials for the two walking trials were used to represent the temporal and kinematic characteristics for each participant during the task. Transitional phase time and peak velocity and acceleration during the transitional phase were calculated using MATLAB (the Mathworks, Inc., MA, USA) from the IMU data. Ensemble Empirical Mode Decomposition (EEMD) (Huang et al., 1999)-Golay was first used to denoise the IMU data. The chosen number of ensembles was 100 with the ratio of the standard deviation of the added noise to that of the signal as 0.2. For the 10-meter walking trials, walking velocity (WV), stance time (ST), double support time (DST), swing time (SwT), step length (SL), total walking time (TWT) and cadence were calculated from the IMUs according to Barth et al (2010).

One-way between-subject ANOVA was performed with group (i.e. obese and non-obese) as the independent variable and gait measures (WV, ST, DST, SwT, SL, TWT and Cadence) as the dependent variables using JMP 9 (SAS Institutes).

3. Result

The mean and standard deviation with the statistical results are provided in Table 2. The one-way ANOVA indicated that there was no significant difference in walking velocity, stance time, double support time, step length, cadence and total walking time to complete the task (p>0.05) between the obese and non-obese groups. However, obese participants walked with significantly less swing time than their non-obese counterparts (p=0.04).
Table 2 Result and ANOVA analysis for non-obese and obese groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Non-obese</th>
<th>Obese</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>WV (m/s)</td>
<td>0.85±0.17</td>
<td>0.95±0.31</td>
<td>N.S.</td>
</tr>
<tr>
<td>ST (s)</td>
<td>0.61±0.086</td>
<td>0.53±0.13</td>
<td>N.S.</td>
</tr>
<tr>
<td>DST(s)</td>
<td>0.22±0.09</td>
<td>0.25±0.15</td>
<td>N.S.</td>
</tr>
<tr>
<td>SL (m)</td>
<td>0.43±0.06</td>
<td>0.38±0.09</td>
<td>N.S.</td>
</tr>
<tr>
<td>Cadence (step/min)</td>
<td>122.11±24.08</td>
<td>124.82±20.88</td>
<td>N.S.</td>
</tr>
<tr>
<td>TWT (s)</td>
<td>12.82±4.74</td>
<td>13.86±6.96</td>
<td>N.S.</td>
</tr>
<tr>
<td>SwT(s)</td>
<td>0.45±0.07</td>
<td>0.41±0.09</td>
<td>*</td>
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</tbody>
</table>

4. Discussion

The objective of this study was to study the gait characteristics between obese and non-obese elderly using a clinically validated gait assessment tool (i.e. 10 meter walking test) (Scivoletto et al., 2011). Epidemiological findings indicated that obese elderly have more prevalence of falls, however, the mechanism of obesity associated falls is not clear. We hypothesized that obesity as quantified by Body Mass Index (BMI) will influence their gait characteristics leading to higher risk of falls.

The results did not show any significant differences in time of task completion between the non-obese and obese groups (Table 2). The insignificance may suggest that the measures of the 10-meter walking completion time may not provide sufficient information to identify differences in the dynamic postural control between obese and non-obese elderly because the completion time may be dependent on several factors, such as muscle strength, balance control, cognition and walking velocity (Liu-Ambrose, et al., 2010). The total completion time is an integrated measure of gait ability, but may not provide insights into the different system degradations and differences between obese and non-obese elderly.

Unlike previous studies, our study did not find significant difference in gait speed, stance time, double support time and step length (Ko et al., 2010; Lai et al., 2008; McGraw et al., 2000; Spyopoulos et al., 1991), which may be attributed the different population (i.e. young adults versus older adults) and different grouping mechanisms (i.e. normal weight and obese individuals in previous study versus non-obese and obese individuals in the current study) between previous and the current study.

Significantly less swing time was found in obese elderly than non-obese elderly, which may suggest decreased balance control in the obese elderly. Due to the quadriceps muscle function impairments in the obese elderly (Maffiuletti et al., 2007), less swing time is more energy efficient to move a heavier limb as well as maintain the upper body balance (Roebroeck et al., 1992). However, swing time alterations may be associated with increased fall risks (Springer, et al., 2006). Therefore, based upon the insignificance in 10-meter completion time between the groups and significant less swing time in the obese, a more sophisticated measurement instrument may be beneficial in terms of predicting fall risks.

5. Conclusion

In conclusion, obese elderly showed less swing time during 10-meter walking tasks compared to their lean counterparts, which may due to the quadriceps muscle function impairment and decreased balance control among obese participants, relating to higher fall risks. However, the evaluation of completion time to perform the 10-meter walking test by itself would not be able to provide sufficient information to identify differences in the dynamic postural control between obese and non-obese elderly. Therefore, a more sophisticated measurement instrument is warranted to provide more insights to the 10-meter walking test.

6. References


