INTRODUCTION

Obesity is a major health concern in the United States (US). Over one billion people worldwide are considered overweight, and of those, 300 million are considered obese [1]. In addition to numerous health conditions, obesity is associated with an increased risk of falls and subsequent injury. Obese individuals fall almost twice as often (27% vs. 15%) compared to non-obese individuals [2] and falls were identified as the most common cause of injuries in the obese (~36% of all injuries) [3]. Overweight or obese older adults would seem to be at an even higher risk for falls. A larger mass will require the person to generate increased torques to control the trunk, but the muscles generating this torque are weakened by sarcopenia [4]. However, the influence of overweight or obesity on balance recovery from a trip in older adults has yet to be investigated.

Therefore, the goal of the current study was to examine the effect of being overweight on balance recovery from a trip in older adults. We hypothesized that due to a higher torque demand for recovery and decreased ability to generate that torque from sarcopenia, being overweight will have a negative effect on balance recovery from a trip.

METHODS

Eight participants (73.9 ± 6.9 years), four overweight and four normal weight, were used in the study. Body mass index (BMI) was used to determine inclusion into the overweight group (28.8 ± 2.4 kg/m²) or normal weight (20.8 ± 2.4 kg/m²) group. A medical screening was performed to exclude participants with any neurological, cardiac, respiratory, otological, or musculoskeletal disorders, or a history of multiple falls within the past year. The study was approved by the Virginia Tech Institutional Review Board, and written consent was obtained from all participants.

Participants walked repeatedly along a 9 m walkway at a self-selected pace while looking straight ahead. They were informed that a trip might occur in any trial and were instructed to, upon tripping, regain their balance and continue walking. After a minimum of 20 walking trials, a 7.6 cm (3 in.) high pneumatically driven obstacle embedded in the floor was triggered manually to elicit a trip in the mid-to-late swing phase of gait. Two nonfunctional dummy obstacles were placed in the walkway so that participants were unaware of where the trip would occur (Figure 1). Also, participants wore a full body harness for the duration of the experiment to prevent a fall to the ground in the event of an unsuccessful trip recovery.

Whole body kinematics, ground reaction forces, and force applied to the harness were recorded. Reflective markers were placed bilaterally over selected anatomical landmarks on the head, arms, trunk, and lower extremities. Marker data were sampled at 100 Hz using a Vicon 460 motion analysis system (Vicon Motion Systems Inc., Lake Forest, CA). Ground reaction forces were sampled at 1000 Hz using a force platform (Bertec Corporation, Columbus, OH) and were used to determine the time of foot contact after the trip.
Trip recovery performance was quantified using maximum trunk flexion angle, maximum trunk angular velocity, and time to maximum trunk flexion angle from trip onset. These measures were selected based upon their importance in successful trip recovery [5, 6].

A Wilcoxon Rank-Sum test was used to analyze differences in trip recovery measures between overweight and normal weight groups. This test was used due to small sample size and non-normal distributions. In addition, effect size was calculated using Cohen’s $d$, the mean overweight value subtracted from the mean normal weight value, divided by the standard deviation of the normal weight value. Statistical analysis was performed using JMP v7 (Cary, North Carolina, USA).

RESULTS AND DISCUSSION

Time to maximum trunk angle from trip onset was 49.5% higher in overweight older adults ($p=0.043$) compared to normal weight adults. Maximum trunk angle and maximum trunk angular velocity were 68.3% and 49.2% higher in overweight adults, but these differences did not reach statistical significance ($p=0.083$; see Table 1).

Reducing trunk flexion and trunk flexion velocity is crucial to recovering balance after a trip [7]. In this study, the overweight group had larger values for all measures calculated. This indicates that the overweight group has decreased ability to arrest forward trunk movement during a trip and will be more likely to fall. More specifically, the overweight group took longer to reach their larger maximum trunk flexion. This indicates that being overweight increases the amount of time the center of mass is outside the base of support, and thereby decreasing the ability to recover balance.

Several limitations warrant discussion. First, we did not account for differences in recovery strategy (elevating vs. lowering) between participants. Second, the small sample size limits our statistical power. Third, participation requirements (medical screening) may preclude the generalization of our results to non-healthy older adults. Finally, it is unclear if results from this study transfer to trips outside of the laboratory setting.

CONCLUSIONS

In conclusion, the overweight older adults exhibited significantly longer time to maximum trunk angle compared to the normal weight group. The overweight group also exhibited trends toward larger values of trunk flexion and trunk flexion velocity. These results suggest that being overweight negatively affects balance recovery after tripping in healthy older adults, and may help to explain the increased risk of falling in these individuals.

REFERENCES

1. WHO Consultation on obesity 1998.

Table 1: Trip recovery measures.

<table>
<thead>
<tr>
<th></th>
<th>Normal Weight</th>
<th>Overweight</th>
<th>Effect Size (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Trunk Angle (deg)</td>
<td>30.6±12.0</td>
<td>51.5±20.4</td>
<td>-1.76 (0.083)</td>
</tr>
<tr>
<td>Maximum Trunk Angular Vel. (deg/s)</td>
<td>111.7±33.9</td>
<td>166.6±27.8</td>
<td>-1.62 (0.083)</td>
</tr>
<tr>
<td>Time to Maximum Trunk Angle (s)</td>
<td>0.49±0.10</td>
<td>0.73±0.10</td>
<td>-2.46 (0.043)</td>
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