OBESITY DOES NOT INFLUENCE THE ABILITY OF YOUNG ADULTS TO RECOVER BALANCE FROM A FORWARD FALL WITH A SINGLE STEP

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INTRODUCTION

Over 33% of US adults, or 72 million, are obese [1]. This total is projected to increase to over 44% by 2020 [2]. Obesity is associated with numerous medical conditions, one of which being an increased risk of falls. For example, obese workers are more likely to experience a fall or multiple falls in the occupational setting [3].

It is possible that the increased risk of falls among the obese may be due to a decreased ability to recover balance after a postural perturbation. Obese individuals exhibit increased postural sway during quiet standing [4] and decreased ability to recover balance using an ankle strategy after perturbations imposing an initial angular velocity on the individual [5]. However, the generalizability of these studies to balance recovery by stepping is unclear. Therefore, the purpose of this study was to investigate the effects of obesity on balance recovery by stepping.

METHODS

Nineteen male subjects, aged 21.5 ± 2.1 years, participated in this study, including nine obese (BMI>30 kg/m²) and 10 healthy-weight (HW: 20<BMI<25 kg/m²). This study was approved by the Virginia Tech Institutional Review Board, and written consent was obtained from all participants.

Participants were repeatedly exposed to two types of perturbations: position perturbations and velocity perturbations. For position perturbations, participants were released from a static forward lean. This resulted in a perturbation involving an initial displacement of the body center of mass (COM) from its base of support with no initial velocity. Perturbation magnitude was quantified by the force (in percent body weight) in a horizontal cable used to hold participants in the forward lean. After release from the forward lean, participants attempted to recover balance with a single step of the right foot.

For velocity perturbations, participants stood on a custom-built TRanslatIng Platform (TRIP). The TRIP was pushed at a constant forward velocity until it impacted a rigid stop at the end of a walkway (Figure 1). This resulted in a perturbation involving an initial anteriorly-directed velocity of the body COM relative to the base of support with minimal displacement from an upright standing posture. Perturbation magnitude was quantified by the speed of the TRIP prior to impact. After impact, participants attempted to recover balance with a single step of the right foot.

For each type of perturbation, perturbation magnitude was systematically increased until participants could no longer recover balance using a single step. 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 recovery.

Figure 1. Photograph of a participant before and after impact of the TRIP during a velocity perturbation trial. An assistant pushed the TRIP and matched speed with a pacing belt.

Whole body kinematics were recorded by placing reflective markers 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) and were used to estimate the whole body COM. Whole body COM was calculated using inertial parameter estimate methods by Pavol et al. [6]. The body angle (θ) and body angular velocity (θ̇) were then calculated from a line connecting the non-stepping (i.e. left) ankle to the body COM, and was measured from vertical.

A Wilcoxon Rank-Sum test was used to investigate the effects of obesity on five dependent variables. From the position perturbations, θ_{MAX} was the largest initial static lean from which balance could be recovered with a single step (measured from markers immediately before release). From the velocity perturbations, θ̇_{MAX}, was the largest body angular velocity immediately after impact from which balance could be recovered with a single step (measured from markers). Liftoff time (i.e. time from perturbation onset to liftoff of stepping toe), step time (i.e. time from perturbation onset to stepping toe contacted the ground), and step length were also compared for each type of perturbation. Statistical analysis was performed using JMP v7 (Cary, North Carolina, USA) with a significance level of p≤0.05.

RESULTS AND DISCUSSION

There was no difference in θ_{MAX} or θ̇_{MAX} between healthy-weight and obese participants (Table 1). Additionally, there were no differences in liftoff time, step time, or step length between healthy-weight and obese participants for either type of perturbation.

In our previous study, obesity negatively influenced balance recovery using an ankle strategy only when perturbations involved an initial angular velocity [5]. It was hypothesized from these results that the increased mass moment of inertia associated with obesity was beneficial for perturbations in which there is limited or no initial velocity, but becomes detrimental as initial velocity increases. In contrast, the current study found no such effect of obesity on balance recovery by stepping. Absolute strength at the hip and knee has been found to be increased in the obese [7]. It is possible that this may help offset the detrimental effects of increased weight and mass-moment of inertia, and would help explain differences in the current study’s results compared to the ankle strategy.

CONCLUSIONS

In conclusion, no differences were found in single step balance recovery ability by stepping between healthy-weight and obese young adults. Additionally, no differences in liftoff time, step time, or step length were found between groups. Future studies will investigate the effects of obesity and aging on recovery after a trip.

REFERENCES


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| Table 1: Balance Recovery Measures (no differences found between healthy-weight and obese participants). |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | **FORWARD LEAN** | **TRIP**        |                  |                  |                  |                  |                  |
|                                | θ_{MAX} (deg)   | Liftoff Time (ms) | Step Time (ms) | Step Length (m) | θ̇_{MAX} (deg/s) | Liftoff Time (ms) | Step Time (ms) | Step Length (m) |
| Healthy-Weight                 | 33.10±2.13      | 169±29           | 495±30          | 1.19±0.13       | 101.53±14.01    | 92±20            | 443±32          | 1.27±0.18       |
| Obese                          | 31.46±2.81      | 192±38           | 517±39          | 1.20±0.11       | 98.71±18.23     | 88±35            | 431±24          | 1.21±0.16       |