PRELIMINARY INVESTIGATION OF SLIP AND TRIP PROPENSITY IN OVERWEIGHT AND NORMAL WEIGHT ADULTS

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INTRODUCTION

Slips, trips, and falls account for approximately 21% and 13% of disabling [1] and fatal [2] occupational injuries, respectively. In addition, obese individuals fall almost twice as often compared to non-obese individuals [3] and falls were identified as the most common cause of injuries in the obese (~36% of all injuries) [4]. This is of concern because over 66% of adults in the United States are considered overweight or obese [5], and this percentage is increasing. Between 1980 and 2002, for example, obesity prevalence doubled among adults and overweight prevalence tripled among children [5]. However, the influence of being overweight on slip and trip propensity has yet to be investigated.

Therefore, the goal of the current study was to investigate differences in slip and trip propensity between overweight and normal weight adults. We hypothesized that due to the reported increased risk of falls in obese individuals, overweight subjects will exhibit an increased slip and trip propensity compared to normal weight subjects.

METHODS

Eight subjects (59.4 ± 26.8 years), including four overweight (body mass index, or BMI, = 28.9 ±1.7 kg/m^2) and four normal weight (BMI = 19.6 ±1.3 kg/m^2) participated in the study. A medical screening was performed to exclude participants with any self-reported neurological, cardiac, respiratory, otological, or musculoskeletal disorders, or a history of multiple falls within the past year.

Subjects walked along a walkway at two prescribed gait speeds: 1.2 m/s (Slow) and 1.5 m/s (Fast). Three trials were completed at each speed. During each trial, the position of selected anatomical landmarks was sampled at 100 Hz using a Vicon 460 motion analysis system (Vicon Motion Systems Inc., Lake Forest, CA), and ground reaction forces were sampled at 1000 Hz using a force platform (Bertec Corporation, Columbus, OH).

Required coefficient of friction (RCOF), the ratio of anterior-posterior shear to normal foot forces generated during gait, was used to quantify slip propensity [6]. A higher RCOF implies that a greater shear force is needed to keep the foot from slipping. Minimum toe clearance, defined as the lowest vertical position of the foot during the swing phase of gait, was used to quantify trip propensity. A smaller toe clearance value implies an increased risk of tripping [7].

A Wilcoxon Rank-Sum test was used to investigate differences in slip and trip propensity between overweight and normal weight groups within each gait speed. This test was used due to small sample size and non-normal distributions. Statistical analysis was performed using JMP v7 (Cary, North Carolina, USA).

RESULTS AND DISCUSSION

The overweight group exhibited a higher RCOF than the normal weight group ($p<0.05$) for both gait speeds (Figure 1). No significant differences were found between the overweight and normal weight group for minimum toe clearance.

A higher RCOF for the overweight group indicates that overweight subjects require more frictional resistance and are more likely to initiate a slip than the normal weight group. Fall risk is dependent upon the number of fall initiating events and balance recovery capability [8]. Our results indicate that overweight individuals may be at an increased risk of falls due to an increased propensity for fall initiating events (i.e. slipping).

Contrary to our hypothesis, the overweight group did not exhibit smaller toe clearance values. These

results imply that the overweight group does not have an increased propensity for initiating a trip. However, being overweight or obese causes alterations in gait, such as smaller strides and longer periods of double support, and it has been suggested that these alterations are an attempt to be more stable during gait [9]. It is possible that these alterations in gait also result in a decreased risk of tripping. To our knowledge, this has not been addressed in previous studies. Though being overweight does not appear to influence the propensity to trip, it may still decrease balance recovery capability from a trip, and thereby increase fall risk.

One limitation to this study was the relatively large range of subject ages. However, studies have found that RCOF and minimum toe clearance are not significantly different between young and older adults [10, 11]. Another limitation is that the small sample size limits the statistical power of our results. It is important to note that even with a small sample size, significant differences were still found for our slip propensity measure, RCOF. Third, our measures were used as a surrogate measure of slip and trip propensity, and the relation between these variables and risk of falls has not been quantified.

CONCLUSIONS

In conclusion, the overweight group was found to have a greater risk for slips, but not for trips, compared to the normal weight group. Future studies should also investigate differences in slip and trip recovery between normal weight, overweight, and obese individuals to help understand the biomechanical mechanisms behind the increased risk of falling in the obese.

REFERENCES

1. Courtney TK, et al. *Ergonomics* **44**, 1118-37, 2001.
2. *MMWR Morb Mortal Wkly Rep* **56**, 297-301, 2007.
3. Fjeldstad C, et al. *Dyn Med* **7**, 4, 2008.
4. Matter KC, et al. *Obesity (Silver Spring)* **15**, 2384-90, 2007.
5. Ogden CL, et al. *Jama* **295**, 1549-55, 2006.
6. Buczek FL, et al. *International Symposium on Slip Resistance - the Interaction of Man, Footwear, and Walking Surfaces* 353-358, 1995.
7. Rietdyk S, et al. *Clin Biomech (Bristol, Avon)* **20**, 1085-93, 2005.
8. Robinovitch SN, et al. *J Neurophysiol* **88**, 613-20, 2002.
9. Spyropoulos P, et al. *Arch Phys Med Rehabil* **72**, 1065-70, 1991.
10. Lockhart TE, et al. *Ergonomics* **46**, 1136-60, 2003.
11. Mills PM, et al. *Hum Mov Sci* **20**, 427-46, 2001.

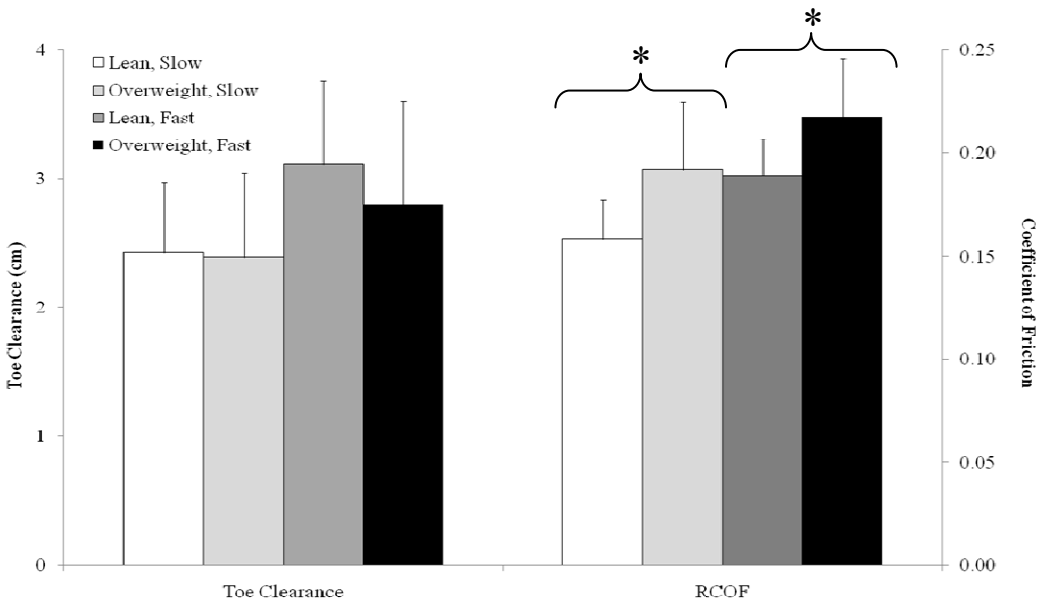

Figure 1: Slip and Trip Propensity Measures for Slow and Fast Gait Speeds. * indicates p-value <0.05