FALL RISKS ASSESSMENT FOR THE COMMUNITY DWELLING OBESE ELDERLY USING WEARABLE SENSORS

[1]Xuefang Wu and [1,2]Thurmon E. Lockhart

[1]Industrial and System Engineering
[2]Biomedical Engineering and Science
Virginia Tech, Blacksburg, VA, 24061
E-mail: xfwu@vt.edu

INTRODUCTION

In the US, 35.7% of the adults, or over 72 million people are obese. Obesity is not only a contributing cause of many physical health conditions, but also associated with structural and functional limitations [1]. One of the concerns is its association with an increased fall risks and subsequent injuries. Falls have been identified as the most common (36%) cause of injuries in the obese. Middle-aged and older obese adults fell almost twice as frequently (27%) as their lean counterparts (15%) per year [2]. Although epidemiological studies clearly indicated increased risks of falls in the older obese population, it is not clear why they fall more. One way to evaluate their increased fall risks among the obese is to study the difference between obese fallers and non-fallers, if there is any.

Clinical tools such as the Activities-specific and Balance Confidence (ABC) Scale, Timed Up and Go test (TUG), Sit to Stand test (STS) and 10 meter walking test have been demonstrated to predict elderly fallers. Older adults who score low on those scales or requiring longer time to complete the TUG/STS tasks have been identified to have higher fall risks. As such, we will evaluate the fall risks of the obese community-dwelling elderly using these clinical tools.

METHODS

Twenty community-dwelling older adults were enrolled in the study after giving informed consent, which was pre-approved by the Internal Review Borad of Virginia Polytechnic Institute and State University. The inclusion criteria were: (1) age 65years or older, (2) ability to understand the nature of the study and provide informed consent, and (4) ability to walk 10 m without gait aids. Individuals with any medical condition or disability that could prevent them from participating in routine clinical balance tests (e.g., TUG) were excluded. After informed consent was obtained, subjects completed questionnaires containing information on age, residential status, medical history, and fall history during the past twelve months. Participants' height, weight and responses to the Activities-specific Balance Confidence (ABC) scale were also obtained. Among all the participants, there are four obese (BMI>30) non-fallers, four non-obese (18<BMI<25) non-fallers and six obese fallers and six non-obese fallers.

Three custom-made wireless inertial measurement units (TEMPO: IMUs), consisting of one triaxial accelerometer and two gyroscopes were attached on participants' sternum and both ankles (lateral sides) to obtain the temporal and kinematic data. Stopwatch was also used. A standard armchair (seat height of 43cm, arm height of 65 cm) was used for participants to perform the "timed up & go" and sit to stand tasks.

Wearing their own footwear, participants were asked to complete the TUG, STS and 10 meter walking tasks. The participants had a chance to walk through the test once before being timed in order to become familiar with the test. The two consequent trials were timed and recorded for the experiment. Two trials were recorded and timed. The sequence of the trials for each participant was randomized.

The mean of the two timed trials for each mobility task (STS, TUG, 10-meter walking) were used to represent the temporal and kinematic characteristics each participant during the task. Transitional phase time and peak velocity and acceleration during the transitional phase were calculated using MATLAB from the IMU data. Ensemble Empirical Mode Decomposition (EEMD)-Golay was first used to denoise the IMU data. For the 10-meter walking trials, walking velocity (WV), gait cycle time (GCT), double support time (DST), stance time (ST), swing time (SwT), swing angle (SA), step length (SL) and cadence were calculated from the IMUs.

Two-way between-subject ANOVA was performed to determine the interaction effect of obesity×fall, the main effect of obesity and the main effect of fall using JMP 9, with significance level of <0.05.

RESULTS AND DISCUSSION

Our results indicated that fallers have lower ABC scores ($F(1,16)=5.6130$, $p=0.03$), slower walking velocity ($F(1,16)=4.3696$, $p=0.05$) and longer TUG time ($F(1,16)=7.4606$, $p=0.01$) compared with their non-faller counterparts. Obese participants had longer sit to stand time ($F(1,16)=4.1357$, $p=0.05$) than their lean counterparts. No interaction effect was found between the obesity and falls. The mean and standard deviation of all parameters for all four groups of participants can be found in Table 1.

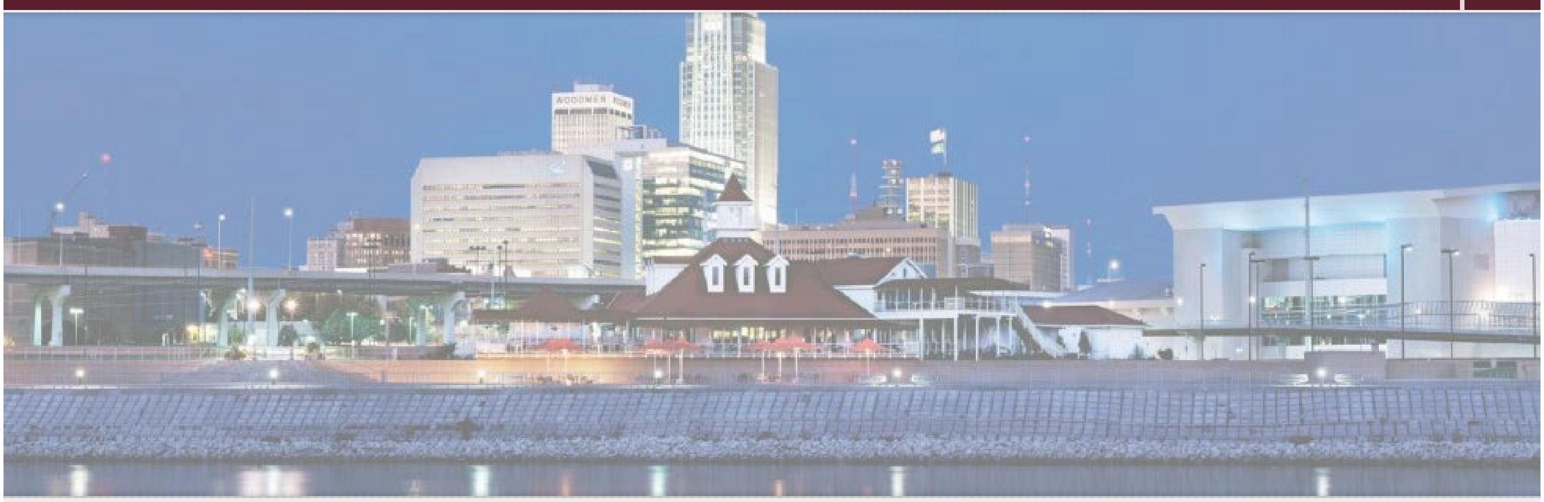
Our study indicated that fallers had a significantly lower ABC score when compared to their non-faller counterparts (Table 1). ABC scores were linked with the psychological factor, referring to the "fear of falling", which has significant implications on an elderly's independence level and results in loss of confidence in performing activities of daily living [3]. Individuals with a fall history are more influenced by the fear of falling complex and seem to be more restricted in their daily activities. Additionally, WV was identified as one of the variables to predict falls. The slowed walking velocity among fallers may reflect degradations in musculoskeletal and sensory systems and lack of confidence in walk safely. Furthermore, our results indicated that fallers took significantly longer time to complete the TUG task than non-fallers. Timed up and go test is designed to assess the four main risk factors associated with the risk of falling among the elderly: 1) strength in lower extremities, 2) coordination, 3) balance, 4) gait. The significant longer completion time among fallers was in agreement with other studies, which indicated that fallers are associated with decreased functional mobility. Decreased functional mobility may be linked to poor muscle strength, poor balance, slow gait speed, fear of falling, physical inactivity, and impairments relating to basic and instrumental activities of daily living. The significant longer STS time among the obese may indicate that obese alterations in dynamic postural control. Our results indicated that obesity does not appear to increase overall fall risk, although some postural control adaptations exist. Larger scale study is warranted to provide more insights in the fall risks of obese.

REFERENCES

1. Hills AP et al. *Obesity Reviews* 3(1), 35-43, 2002.
2. Fjeldstad C et al. *Dynamic Medicine* 7 (4), 27, 2008
3. Lajoie Y and Gallagher SP. *Archives of Gerontology and Geriatrics*, 38: 11-26, 2000.

Table 1: Results for obese and non-obese fallers and non-fallers

	Non-Obese		Obese	
Parameter	**Non-Fallers**	**Fallers**	**Non-fallers**	**Fallers**
ABC score	87.68±16.72	64.93±10.89	73.25±19.52	67.4±13.60
Walking Velocity ($m*s^{-1}$)	1.02±0.17	0.92±0.10	1.12±0.25	0.81±0.17
Sit to Stand Time (s)	2.80±1.29	3.70±1.71	4.96±2.05	5.84+1.85
Timed up and go completion time (s)	7.68±1.16	9.32±1.57	7.78±0.77	11.30±1.27
Gait Cycle Time (s)	0.92±0.27	1.16±0.14	0.91±0.23	0.95±0.24
Double Support Time (s)	0.23±0.11	0.28±0.12	0.18±0.12	0.28±0.18
Stance Time (s)	0.54±0.18	0.70±0.13	0.50±0.11	0.54±0.21
Swing Time (s)	0.41±0.07	0.43±0.09	0.43±0.06	0.41±0.10
Swing Angle (°)	32.64±5.33	33.94±5.02	31.29±6.63	28.85±6.60
Step Length (m)	0.41±0.07	0.44±0.07	0.39±0.09	0.38±0.08
Cadence ($step*min^{-1}$)	118.26±17.46	111.62±12.26	129.14±22.55	119.51±19.64



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