INTRODUCTION

Approximately one-third of older adults (65 years or older) are reported to have fallen annually. Most falls in elderly adults occur during daily activities [1,2]. Many of these activities require successful movement transitions, such as from sitting to walking. Sit-to-walk (STW) is not a sequential arrangement of two individual tasks but requires a smooth transition from sit-to-stand (STS) to gait initiation at seat-off instant [3]. However, such smooth transition is not observed in elderly adults [4,5]. Compared to young individuals, elderly adults generated a less horizontal center of mass (COM) momentum at seat-off in order to maintain a more stable upright posture before walking [4,5].

While the COM motion has been described for elderly adults during STW, investigating relation between movement strategy and joint kinetic during STW can aid in understanding potential mechanisms behind an altered STW in elderly. Therefore, the purpose of this study was to examine the differences in the movement strategy and joint kinetics during STW among three groups: healthy young adults (YA), healthy elderly adults (EA) and elderly fallers (EF).

METHODS

Ten healthy YAs (age = 25.0 ± 2.76 yrs), ten EAs (age = 77.0 ± 4.3 yrs) and ten EFs (age = 77.7 ± 9.3 yrs) have been recruited and tested in this study. EFs were those who had reported two or more falls in the prior year. Subjects were instructed to stand up from a bench, walk 3 meters, turn around, return to the chair and sit down at a self-selected speed (TUG). Subjects were told that they will be timed during the task. Whole body motion data were captured with an 8-camera motion analysis system (Motion Analysis Corp., Santa Rosa, CA). A total of 29 markers were placed on the subject’s bony landmarks [6]. An adjustable height bench was placed on one force plate in order to detect the seat-off point of the STW period. The other force plate was placed under the foot that supports the subject’s weight while he/she stands up.

Inclination angle of the line formed by the COM and lateral ankle marker of supporting limb was computed for each frame during STW. Sagittal plane trunk angle is also identified during STW. The hip, knee and ankle joint flexion/extension moment and the propulsion and braking impulse of the supporting limb (stance limb) during STW were investigated.

RESULTS AND DISCUSSION

The time required to complete TUG for YA, EA and EF were 7.94 ± 0.94 (STW: 1.32 ± 0.16), 9.90 ± 1.53 (STW: 1.48 ± 0.15) and 12.70 ± 3.84 (STW: 1.90 ± 0.57) seconds, respectively.

The magnitude of anterior-posterior COM-Ankle angle (AP COM-Ankle angle) was significantly greater in YA and EA than EF at seat-off (-4.06 ± 2.31, -3.03 ± 2.57, 0.51 ± 2.19, \(p < 0.001, p = 0.007\) respectively). A negative value indicates that COM is located posterior to the ankle position. A small AP COM-ankle angle suggested that EF placed their COM within the base of support to achieve a stable posture before gait initiation. Sagittal plane trunk angles at seat-off did not differ significantly among groups (YA=36.5°, EA=31.4°, EF=32.9°, \(p = 0.333\)). These results indicated that EF did not bend their trunk excessively to bring their COM closer to the supporting limb, instead they changed the ankle position.

While COM-ankle angle provide posture alignment information, ground reaction forces (GRF) and joint kinetics of the supporting limb can
provide insight into the underlying mechanisms of muscular control. All groups demonstrated a braking impulse follow by a propulsive impulse at push off as shown by the AP GRF (Figure 1). When compared to YA and EA, EF demonstrated a significantly greater braking impulse and smaller propulsive impulse ($p < .001$). This greater braking impulse is used to reduce the forward COM momentum, and results in a longer STW time. The braking impulse in STS has been reported to be greater than the braking impulse during STW motion [3]. This could indicate that EF attempted to achieve an upright position before initiating gait.

### Figure 1: Mean forward GRF of the supporting limb during STW for YA, EA and EF.

YA demonstrated a trend of generating a larger hip extensor moment at seat-off than EA and EF (0.83 ± 0.16, 0.66 ± 0.31, 0.67 ± 0.14 respectively, $p = 0.179$). Smaller hip moment may suggest that EA and EF have relatively weaker hip extensor muscle. The knee extensor moment did not differ among groups (0.58 ± 0.19, 0.56 ± 0.24, 0.52 ± 0.17 respectively, $p = 0.770$). Significant differences in the sagittal plane ankle moment were found between groups at seat-off and swing-off (Figure 2, $p < .001$). Both YA and EA showed a dorsi-flexor moment while EF demonstrated a plantar-flexor moment at seat-off and swing-off. This could be related to the reduced ankle dorsi-flexor strength that has been reported in elderly adults with a history of multiple falls [7]. In addition, due to a reduced forward COM momentum and smaller hip/knee extensor movements, EF had to use their ankle plantar-flexor to push up to a standing position.

### Figure 2: Mean sagittal plane angle joint moment of the supporting limb during STW for three groups. A negative value indicates a dorsi-flexor moment.

### CONCLUSION

The results of this study suggest that EF tried to maintain a stable posture prior to walking during this dynamic STW task. They adjusted their foot (ankle) positions so that their COM could be located slightly anterior to ankle. In addition, EF increased the braking impulse to reduce their forward COM momentum. With small hip and knee extensor moments in EF, the above mentioned adjustments result in a greater ankle plantar-flexor moment at seat-off during STW.

### REFERENCES