INFLUENCE OF ASYMMETRY OF LOWER EXTREMITY FORCE ON CENTER OF MASS VELOCITY DURING A SIT TO STAND TASK AMONG SUBJECTS WITH HIP FRACTURE

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INTRODUCTION

Physical decline after a hip fracture is associated with changes in movement strategies that affect functional status. Recent studies of subjects post hip fracture demonstrate greater force (vertical ground reaction force[vGRF]) of the uninvolved limb during the rising phase of a sit to stand (STS) task[1]. Yet, how the preference of subjects post hip fracture for the uninvolved side influences center of mass (CM) defined movement strategies during a STS task is unclear. Healthy elderly subjects compared to subjects with mobility limitations are characterized by: higher horizontal CM velocity, and decreased sit to stand time. [2,3] Subjects with mobility limitations use CM horizontal velocities lower than 0.4 m/s during a STS task. The lower CM horizontal velocity is thought to be an adaptation to maintain stability as the individual moves the CM over the base of support[2]. In contrast, CM vertical velocity may be lower in the presence of strength deficits and learned preference for the uninvolved limb (higher vGRF of the uninvolved limb) [4]. The purpose of this study was to compare CM velocity (horizontal and vertical) and vGRF(involved/uninvolved) during the rising phase of a STS task in subjects post hip fracture.

METHODS

Fourteen individuals with hip fracture (5 male, 9 female; age=78 ± 6) and 15 elderly controls (3 male, 12 female; age=69 ± 10) volunteered for this study. Surgical procedures for hip fractures included hemiarthoplasty (8) and ORIF (6). Subjects were between 2-12 months post hip fracture and were currently discharged from care.

An Optotrak Movement Analysis System (Northern Digital, Inc, Waterloo, CANADA) and force plate (Kistler, Amherst, NY) integrated with The Motion Monitor software (Innsport, Inc, Chicago, IL, USA) was used to measure ground reaction force. To

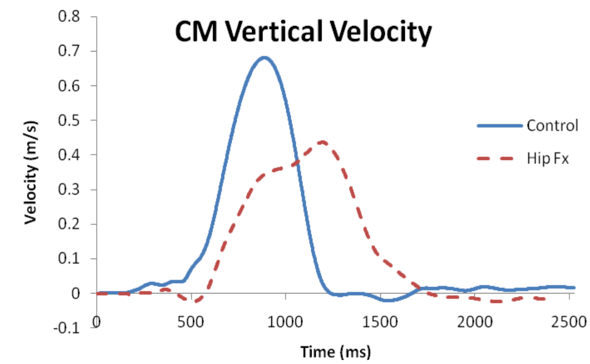

Figure 1: Example of CM vertical velocity for an elderly control (solid line) and hip fracture subject (dotted line).

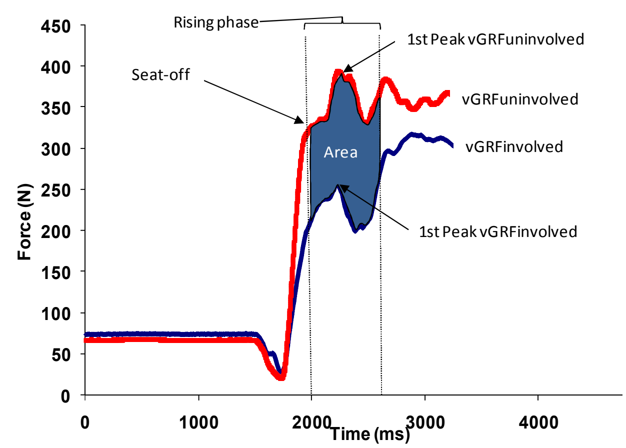

Figure 2: The unilateral measures of vGRFinvolved/uninvolved were determined from the left and right force plates. Symmetry during the rising phase was calculated as the area between the vGRFinvolved and uninvolved throughout the rising phase.

assess lower extremity force, four force plates were used to record GRF under each leg (unilateral), the trunk (bilateral) and the seat (bilateral) at a sampling rate of 1000 Hz during a STS task. The STS task was performed 3 times without hands. The rising phase was determined from seat off (start of rising phase) to the point of level body weight (end of rising phase). The vertical and horizontal GRF, were divided by mass, and integrated with respect to time, to determine CM (horizontal and vertical) velocity during the rising phase of the STS task (Figure 1). Gravity was taken into account in determining vertical CM velocity. Preference for the uninvolved limb was defined as the AREA between the vGRF of the involved versus uninvolved side during the rising phase (Figure 2). Peak horizontal and vertical velocity of the CM, AREA, and peak vGRF during the rising phase were compared between the controls and subjects post hip fracture using two sample t – tests. Pearson Product Moment correlations were used to explore the univariate correlations among variables.

RESULTS AND DISCUSSION

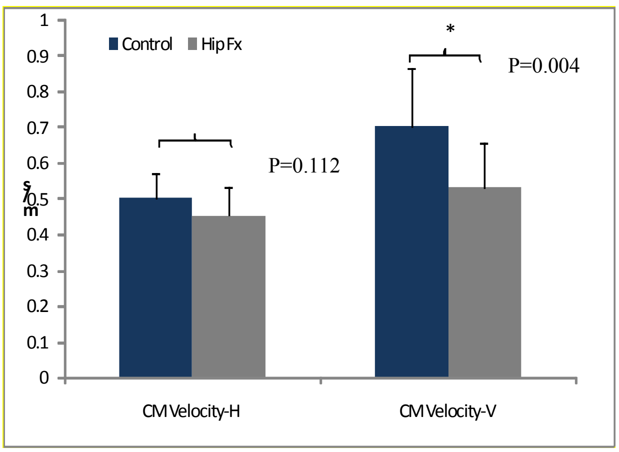

Figure 3: CM velocity horizontal and vertical for both hip fracture and control subjects. P-values are results of a 2 sample t-test.

The new findings of this study show that subjects with hip fracture exhibit significantly lower vertical CM velocities (p=0.004, HF = 0.45m/s ± .08 vs Cont = .50m/s± .07) during a sit to stand task (rising phase) while maintaining similar horizontal CM velocities compared to controls (p=0.11, HF = 0.53m/s ± .12 vs Cont = .70m/s± .16) (Figure 3). Additionally, subjects with hip fracture tended to rise with a preference for the uninvolved side (Area:p=0.008, HF = 1.25 N*s/Kg ± .85 vs Cont =0.53N*s/Kg ± .22), relying 20-30% less on their involved limb (Peak (vGRF) involved:p=0.009, HF = 5.37 N/Kg ± .84 vs Cont = 6.43 N/Kg ± 1.18) compared to their uninvolved limb (Peak (vGRF) uninvolved:p=0.79, HF = 6.62 N/Kg ± 0.67 vs Cont = 6.52 N/Kg ± 1.33). A moderate correlation was observed between CM velocity vertical and Area (p=.005: r=.703) for the hip fracture group. The reliance on the uninvolved side has a much stronger influence on CM velocity vertical than the horizontal. Theoretically the lower CM velocity may result from a learned movement strategy to slow down CM velocity vertical in order to minimize falls risk. A higher CM velocity vertical in the presence of 20-30 % vGRF asymmetry may push the CM close to the limits for maintaining balance. Therefore a slower CM velocity vertical may be a compensation to decrease falls risk post hip fracture, explaining the correlation between AREA and CM velocity vertical. Strength deficits may also contribute and are amenable to progressive resistance training. New training programs seeking to return subjects post hip fracture to pre-morbid status may consider evaluating these alterations of lower extremity force and CM velocity.

CONCLUSIONS

Hip fracture subjects transitioned from sit to stand with decreased vertical CM velocity and higher vGRF on the uninvolved side despite being discharged from rehabilitative care. Decreases in vertical (rather than horizontal) CM velocities may represent compensatory movement strategies associated with falls risk in subjects post hip fracture.

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