Evaluating Robotic Assistance for Standing Up and Sitting Down in Frail Older Adults

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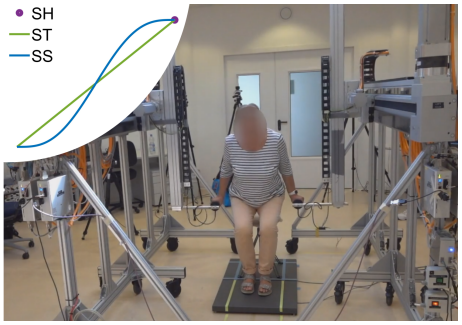

Figure 1: Experimental setup with robotic rollator simulator and handle trajectories (top left): static handle (*SH*), straight trajectory (*ST*), S-shaped trajectory (*SS*).

Summary

Robotic rollators with moving handles can support frail older adults in and out of a chair, but the robot-user interaction is poorly understood and optimal trajectories are unknown. Here we investigate 2 moving-handle versus 1 static-handle (ideal normal rollator) conditions using a robotic rollator simulator device by measuring the vertical and horizontal forces as indicators of support provided and rollator stability. The results for 18 frail older adults show that moving handles substantially increased vertical support and reduced horizontal forces, mitigating the risk of the rollator tipping over, compared to the static-handle condition.

Introduction

Standing up (SiToSt) and sitting down (StToSi) are important yet challenging activities, particularly for frail older adults [1]. Robotic rollators equipped with moving handles can provide external support to reduce the large required lower limb joint moments [2]. However, the best and safest assistance trajectories are still unknown, and the human-robot interaction is poorly understood. We previously proposed and evaluated a set of bio-inspired assistance trajectories with younger adults [3]. Here, we investigate the performance of the two best-performing trajectories in frail older adults.

Methods

18 frail older adults (15 female, 83.7 ± 5.6 yrs), with a median *Clinical Frailty Scale* (CFS) of 5 (IQR of 2) and difficulties standing up unassisted, performed 5 repetitions of standing up and sitting down for the 3 assistance conditions in randomized order: straight trajectory (*ST*), S-shaped trajectory (*SS*), and static-handle condition (*SH*) (Fig. 1). The trajectories were imposed by a rollator simulator device composed of two cartesian robots placed at each side of the participant (Fig. 1). The vertical and horizontal forces applied to the participant's hands were collected by load cells attached to the handles (Robotiq FT 300) and filtered (zero-lag BW, 6 Hz). The forces at both sides were summed, and the peak values were taken and averaged over repetitions.

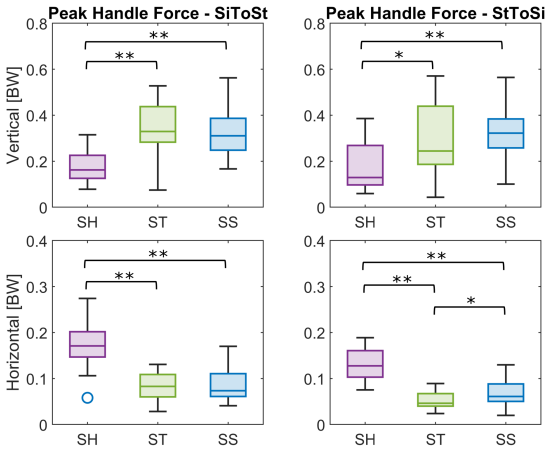

Figure 2: Peak vertical (top) and horizontal (bottom) forces in stand up (left) and sit down (right) as a fraction of body weight (BW) with statistical differences as * ($p \leq 0.05$) or ** ($p \leq 0.01$) .

A repeated measures ANOVA was performed with a post hoc analysis and Bonferroni adjustment. The protocol was approved by the Ethics Committee of the Medical Faculty Heidelberg. Participants provided written informed consent.

Results and Discussion

Figure 2 shows that the peak vertical forces applied by the handles are about double as large for moving handles compared to static handles, reaching about 35% of body weight, and evidencing an increase in provided support in both SiToSt and StToSi. Further analysis will confirm if this translates into reduced lower limb joint moments, as observed in younger adults [3]. The substantial reduction in horizontal forces with moving handles is an important additional finding as it contributes to the stability of the rollator by decreasing its CoP displacement and mitigating the risk of tipping over. It is noteworthy that the static handles are stable, a condition that differs from the one in normal rollators. There were mostly no significant differences in peak forces between *SS* and *ST*.

Conclusions

The results show that moving handles can increase the support to frail older adults in standing up and sitting down and improve rollator stability compared to static handles.

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