Movement Objectives in the Sit-to-Walk Task

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I. Background

An important daily life activity is standing up from a seated position and transitioning into gait. Standing up has been widely studied in biomechanics experiments, however most studies have imposed standardizations on protocol, so the possibility of compensation was restricted [1]. For example, most studies did not permit participants to compensate using their arms and did not study the transition into walking. However, from the onset of age-related physical decline (mid-twenties) until the point that movement impairments arise, compensation is part of human movement strategies. Compensation can therefore be a clinically relevant early indicator of physical decline. Scientifically compensation is interesting as it tips the hand on how humans within the functional redundancy of the neuromuscular systems select a movement strategy. The aim of this experimental study was to capture unrestricted compensation in the sit-to-walk task and relate this to neuromuscular capacity and movement objectives (psychological considerations) in young and older adults.

II. Method

This study (N=50) comprises 14 young women (YW) (age: 27.1±5 years), 13 young men (YM) (27.3±4.3), 12 relatively healthy older women (EW) (75±5.6), 11 relatively healthy older men (EM) (76.8±7.2). All participants gave their informed consent. Participants sat down on an instrumented chair with instrumented armrests with the seat at approximately knee height. Participants were asked to stand up and walk to a table 3m in front of them: 5x at self-selected speed, 5x at fast speed. No instructions were given in their movement strategies. Participants were asked to stand up without using their arms at the end of the experiments, which all participants were capable of. Their kinematics (Vicon) and muscle activity (Delsys EMG) were recorded. Additionally, to assess their neuromuscular capacity, we measured their maximum peak isokinetic joint moments for the knee, hip, ankle, and elbow on a dynamometer (Cybex), handgrip strength (Jamar), balance in a standing balance task, proprioceptive acuity with an ipsilateral matching task of knee flexion, joint range of motion of the hip and ankle (Cybex), and nerve conductivity and maximal muscle excitation with a nerve conduction test. To assess psychological considerations, a questionnaire reviewed their (former) profession, levels of activity, diet, general health, experienced injuries, level of frailty (Edmonton), fear of falling (FES-I short), hearing, level of Dizziness, hand dominance (Edinburgh), and pain (visual analogue scale).

For the purpose of this abstract we will focus on the results of the foot positioning and the applied arm strategies.

III. Results and Discussion

Contrary to what was expected, the older adults used a smaller base of support than the young, even when corrected for pelvis width. This is opposite to the findings in gait, where it is widely accepted that age-related decline leads to a wider walking gait [2]. The width of the base of support had a significant positive relationship to joint strength: participants with higher strength had a wider base of support. We reason that placing the feet wider apart biomechanically requires larger lower-limb muscle forces while standing up. We hypothesize that age-related decline of the lower limb strength leads to a narrow BOS in standing up. This is an important finding, as the BOS is closely linked to stability and falls.

Four arm strategies were observed: standing up without arms, swinging the arms, pushing off on the knees, and pushing off on the armrests. There was a distinct result: EM used an arm push off in 91% of all trials (N=55) at self-selected speed, and in all trials at fast speed, whereas YM, YW and EW only pushed off in less than half of all trials. We therefore hypothesized that EM had less lower limb joint strength than the other groups. However, their peak isokinetic strength corrected by bodyweight did not differ significantly from YW and was mostly higher than EW for all measures. Also, no differences were found between the means of the arm strategy groups with proprioceptive acuity, balance scores, hand grip strength, muscle excitation, or nerve conduction. Nor with the anthropometric data (BMI, length, weight), FES-score (fear of falling), or frailty score. The only significant difference was that the participants with an arm push-off had a significant lower hip flexion range of motion ($p<0.05$) and a lower ankle plantar-flexion range of motion ($p<0.01$). This is in line with previous findings that joint range of motion is a relevant movement objective [3].

IV. Acknowledgements

NWO-ENW VENI Grant 18145

V. References

[1] van der Kruk et al. (2021). 10.1016/j.jbiomech.2021.110411.
[2] Osoba et al. (2019) 10.1002/lio2.252
[3] Beissner et al. (2000) DOI: 10.1093/ptj/80.6.556