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The Fukuda Stepping Test Is Influenced by Stepping Height and by a Concurrent Cognitive Task

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Background/Rationale. The Fukuda Stepping Test (FST) is used to assess patients with vestibular disorders (Hickey et al., 1990). It consists in **stepping in place for 50 steps with the eyes closed**. Healthy people move forward by 86 cm on average and turn up to 30°, without perceiving their body displacement (Fukuda, 1959; Bonanni & Newton, 1988). These unperceived displacements are likely influenced by the height at which the knees are lifted and by mental distractions, but these effects have not yet been investigated.

Research Objectives. To compare linear and angular body displacements at the end of the of the 50 steps between comfortable and high stepping, and between performing a concurrent cognitive task or not in healthy individuals.

Relevance. Specific instructions regarding knee height and careful control of distractions may be needed when performing the FST to ensure unbiased results.

Design. This study is a repeated measures within-subject design.

Participants. Sixteen healthy individuals. They were aged between 20 and 26 years old. There was 12 women and 4 men.

Experiment. Participants performed the FST under **4 conditions** (5 trials per condition):

- at comfortable stepping height, i.e. approx. 45° of hip flexion.
- at comfortable stepping height with a concurrent continuous digit counting task.
- at high stepping, i.e. approx. 90° of hip flexion.
- at high stepping with a concurrent continuous digit counting task.

Data Collection and analyses. Antero-posterior (AP), medio-lateral (ML) and angular (rotation) body displacements in the horizontal plane relative to the start position and vertical knee displacements were recorded with a 3-D motion analysis system (Vicon512™). Comparisons among conditions were made with 2-way ANOVAs.

Results. Height with which the knees were lifted in cm (1 Standard Deviation)

Normal knee height

Single Task	15.0 (5.8)
with Cognitive Task	13.8 (5.2)

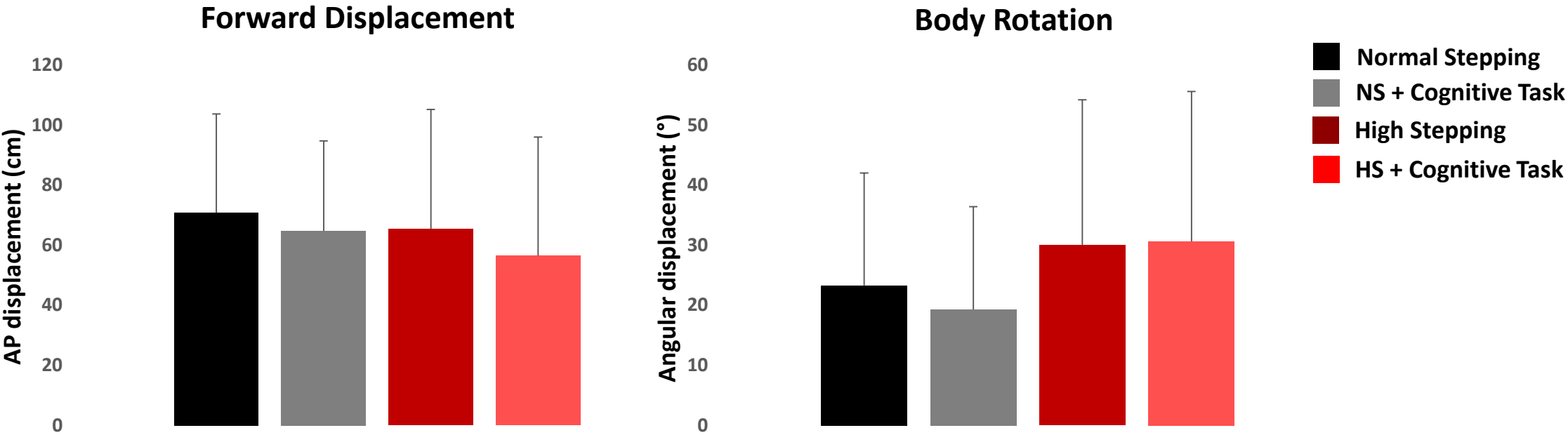
High knee height

Single Task	31.1 (11.3)
with Cognitive Task	29.9 (9.6)

Findings: Significant main effects of Cognitive Task
Significant main effects of Stepping Height

RESULTS

Body displacements at the end of the 50 steps



Significant main effect of Cognitive Task

Significant main effect of Stepping Height

Discussion.

The **decreased AP displacement with the cognitive task** could be due to

- (1) The lower stepping height obtained with than without the Cognitive Task. Our study showed that lower stepping height was associated with shorter AP displacements.
- (2) A shift of attention away from the dynamic postural control while performing the Cognitive Task. It may have allowed for a more unconstrained mode of regulation (Wulf, McNevin & Shea, 2001), also proposed to explain why postural control improved under dual task conditions (Huxhold et al. 2005).

The **larger Body Rotation at high stepping** may be due to biomechanical factors.

- (1) Complex patterns of muscle activation are required to flex the hip and knee on one side, and at the same time to stabilize the trunk, hip and ankle of the supporting leg. Controlling the body center of mass was likely more difficult at high than at normal stepping height and thus, body sway was probably larger.
- (2) The lifted foot is more distant to the ground in the high stepping condition, which makes the repositioning of this foot at the same spot on the ground from which it was lifted more unlikely at high than at normal knee height. As a result, the progressive body rotation was accentuated in the high knee condition.

Conclusion. Stepping height and a concurrent cognitive task were found to influence linear and angular body displacements during the 50-step Fukuda Stepping Test in healthy young adults.