Gait & Posture 48 (2016) 226–229

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Sit-to-walk and sit-to-stand-and-walk task dynamics are maintained during rising at an elevated seat-height independent of lead-limb in healthy individuals

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ARTICLE INFO

Article history:
Received 20 July 2015
Received in revised form 4 June 2016
Accepted 6 June 2016

Keywords:
Healthy subjects
Normative Data
Sit to walk
Seat Height
Lead Limb
Rehabilitation

ABSTRACT

Introduction: Sit-to-walk (STW) is a common transitional motor task not usually included in rehabilitation. Typically, sit-to-stand (STS), pause, then gait initiation (GI) before walking is used, which we term sit-to-stand-and-walk (STSW). Separation between centre-of-pressure (COP) and whole-body centre-of-mass (BCOM) during GI is associated with dynamic postural stability. Rising from seats higher than knee-height (KH) is more achievable for patients, but whether this and/or lead-limb significantly affects task dynamics is unclear. This study tested whether rising from seat-heights and lead-limb affects STW and STSW task dynamics in young healthy individuals.
Methods: Ten (5F) young (29 ± 7.7 years) participants performed STW and STSW from a standardised position. Five trials of each task were completed at 100 and 120%KH leading with dominant and non-dominant legs. Four force-plates and optical motion capture delineated key movement events and phases with effect of seat-height and lead-limb determined by 2-way ANOVA within tasks.
Results: At 120%KH, lower peak vertical ground-reaction-forces (vGRFs) and vertical BCOM velocities were observed during rising irrespective of lead-limb. No other parameters differed between seat-heights or lead-limbs. During GI in STSW there was more lateral, and less posterior, COP excursion than expected.
Conclusion: Reduction in vGRFs and velocity during rising at 120%KH is consistent with reduced effort in young healthy individuals and is likely therefore to be an appropriate seat-height for patients. Lead-limb had no effect upon STSW or STW parameters suggesting that normative data independent of lead-limb can be utilised to monitor motor rehabilitation should differences be observed in patients. STSW should be considered an independent movement transition.

1. Introduction

Rising from sitting and the transition to goal-orientated walking are important for independent living. Such transitions include sit-to-stand (STS) and sit-to-walk (STW) where STS is merged with gait-initiation (GI). STS-GI separation, or hesitation [1], can occur in STW and is synonymous with a critical reduction in forward momentum during rising. Separation has been observed during STW in individuals with motor impairment [2,3]. STW is however rarely utilised as a rehabilitation task presumably due to its higher complexity [4]. Instead, in order to manage task complexity and other risks of being upright (e.g. orthostatic intolerance [5]), STS is separated from GI via insertion of a pause after rising in clinical practice, which we term sit-to-stand-and-walk (STSW).

Subjectively, patient groups find rising from high seat heights easier [6], although the effect this has on STW and STSW task dynamics is unclear. Furthermore, whilst patients tend to lead with their affected limb [2], it is unknown whether generation of separate normative dominant and non-dominant lead-limb data-sets is necessary in order to facilitate assessment of postural stability recovery.

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http://dx.doi.org/10.1016/j.gaitpost.2016.06.005
0966-6362/

A stereotypical feature of normal GI from quiet-standing, and during STW, is the controlled separation of centre-of-pressure (COP) and whole-body-centre-of-mass (BCOM) [4]. The horizontal distance between them (COP-BCOM distance) can characterise dynamic postural control: where intact control is indicated if greater distances are tolerated [7].

Thus the aims of this study were to determine whether seat-height and lead-limb affects STW and STSW temporal and kinematic task dynamics including COP-BCOM distance in young healthy individuals.

2. Methods

2.1. Participants

Ten healthy undergraduate students gave written informed consent to participate in the study that had received local research ethics committee approval (UREC1413/2014).

2.2. Measurements

Participants attended the gait laboratory once, and following mass and height measurement (Seca, 763 scale-stadiometer), completed 5 trials (at self-selected speed) of 8 conditions: STW and STSW, initiated with either dominant (Dom) or non-dominant (NonDom) limb, at 100% knee-height (KH; floor to knee-joint distance) or 120%KH. Participants sat on an instrumented (300 mm diameter pressure-mat, Arun Electronics Ltd, Sussex, UK) height-adjustable stool (Svenerik, Ikea, Sweden) with feet in parallel, shoulder width apart, upon separate force-plates to capture ground reaction forces (GRFs) during rising (Fig. 1).

Participants were cued to rise upon illumination of a light (6 m in front) with the task of operating a switch (5 m in front of them) to turn it off. In STSW participants paused in standing (mentally count from 1-3) before walking, whereas STW required walking immediately upon rising.

A 3D whole-body model was defined by placing 40 reflective markers (Qualysis AB, Sweden) on skin overlying anatomical landmarks [8]. Segments were reconstructed by tracking trajectories using 31 additional markers mounted in accordance with a six degrees-of-freedom marker-set [8]. Kinematic data were acquired using eight infra-red cameras (Oqus-3, Qualisys AB, Sweden) sampled at 60 Hz and synchronously recorded with the following analogue inputs at 1020 Hz: 4 force-plates (9281E, Kistler Instruments Ltd., UK), the stool pressure-mat, and the light-switch.

2.3. Data analysis

Raw marker trajectories and analogue data were imported into Visual3D (C-Motion Inc., USA). The light and pressure-mat analogue signals were average-filtered over a 25-frame window. The marker and GRF data were first smoothed (10 Hz and 25 Hz 4th order low-pass Butterworth filter respectively [4]) before estimation of BCOM and net COP positions from 4 force-plates. Movement events for STW and STSW (Supplementary Table S1a) permitted the delineation of temporal and kinematic variables (Supplementary Table S2) with respect to the task phases (Supplementary Table S1b) [2,3,9,10].

2.4. Statistics

All data were normally distributed (Kolmogorov-Smirnov 1-sample test, PASW v18.0, IBM Corp., USA). Therefore, the effect of seat-height (100%KH, 120%KH), lead-limb (Dom, NonDom) and their interaction were determined via performance of a two-way repeated measures ANOVA with statistical significance assumed at $p \leq 0.05$.

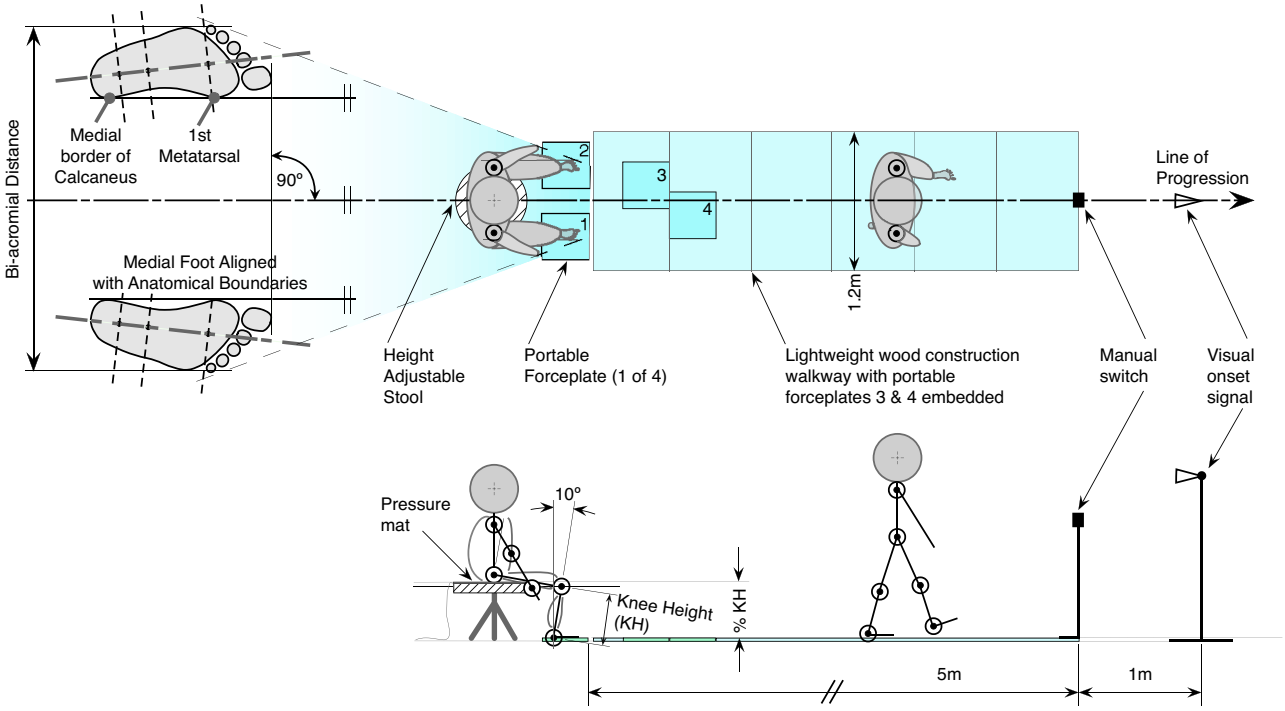

Fig. 1. Experimental Protocol. This example shows left-leg lead configuration: Participants sat on an instrumented stool at either 100 and 120% knee height (KH), with ankles 10° in dorsiflexion, and feet at shoulder width apart orientated forward. In both STW and STSW conditions on a visual cue, participants rose with their feet on independent portable force-plates and walked forward over two further portable force-plates. Participants performed 5 trials at both seat-heights and lead-limb at self-selected pace. The configuration of force-plates 3 and 4 were changed to allow right lead-limb.