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Short communication

# Repeatability of stance phase kinematics from a multi-segment foot model in people aged 50 years and older

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ABSTRACT

Confidence in 3D multi-segment foot models has been limited by a lack of repeatability data, particularly in older populations that may display unique functional foot characteristics. This study aimed to determine the intra and inter-observer repeatability of stance phase kinematic data from a multi-segment foot model described by Leardini et al. [2] in people aged 50 years or older. Twenty healthy adults participated (mean age 65.4 years SD 8.4). A repeated measures study design was used with data collected from four testing sessions on two days from two observers. Intra (within-day and between-day) and inter-observer coefficient of multiple correlations revealed moderate to excellent similarity of stance phase joint range of motion (0.621–0.975). Relative to the joint range of motion (ROM), mean differences (MD) between sessions were highest for the within-day comparison for all planar ROM at the metatarsus-midfoot articulation (sagittal plane ROM 5.28 vs. 3.98, MD 3.18; coronal plane ROM 3.9 vs. 3.18, MD 2.38; transverse plane ROM 6.88 vs. 5.168, MD 3.58). Consequently, data from the metatarsus-midfoot articulation in the Istituto Ortopedico Rizzoli (IOR) foot model in adults aged over 50 years needs to be considered with respect to the findings of this study.


## 1. Introduction

Concerns have been raised regarding a paucity of data on the repeatability of joint kinematics from multi-segment foot models [1]. Good repeatability of the IOR foot model published by Leardini and colleagues [2] has been reported in young adults and individuals with gross foot deformity [3–5]. However, repeatability in healthy older adults has not been reported despite differences in foot characteristics [6] and spatiotemporal gait variables [7], which may impact upon repeatability. This study aimed to determine the intra and inter-observer repeatability of stance phase kinematic data from the IOR foot model [2] in adults aged 50 years or older.

## 2. Methods

### 2.1. Participants

Twenty healthy adults (6M:14F) aged over 50 years participated (mean age 65.8 SD 8.0, range 50–85 years, height 1.66 m SD 0.11, mass 70.6 kg SD 14.4, BMI 26.1 SD 3.9). Exclusion criteria were pain in the feet, knees or hips in the past 30 days, previous orthopaedic surgery of the lower limbs or spine, leg oedema, rheumatoid arthritis, neuromuscular or neurodegenerative disease or history of stroke. Institutional ethics approval was granted for this study (protocol #24952).

### 2.2. Data collection

Participants attended on two days for a total of four testing sessions (two sessions on each day, separated by a 15 min). Test days were scheduled between seven and ten days apart. Observer one (podiatrist) conducted three sessions (two on day one and the first on day two) and observer two (physiotherapist) conducted one session (final session on day two). Surface markers were placed on anatomical landmarks in accordance with the IOR foot model protocol [2]. Marker application guidelines were created, followed by a 1 h training session with both observers [8]. Trajectories of surface markers were acquired with 12 optoelectronic cameras at 100 Hz (FLEX V100:R2, OptiTrack, Natural Point, USA). The capture volume was approximately 2 m long × 1.5 m wide × 1.8 m high. Five walking trials were obtained for each participant in each session. Only right lower limb data were collected [9].

### 2.3. Data processing

Data were exported to Visual3D (v 4.0, C-motion Inc., USA). Marker trajectory data were filtered at 6 Hz [10]. A global optimisation algorithm was applied [11] with all joints constrained to three rotational degrees of freedom (DOF) except the hallux (1 DOF). Each segment (except the hallux) was the parent segment for the one directly inferior. Inverse kinematics were computed for all frames when all lower limb marker trajectories were apparent. Two virtual markers were created from the hallux marker 2 cm along the x-axis of the metatarsus local coordinate system (originally described in [2]) to create the hallux segment. 3D stance phase joint angles (not normalised to standing posture) were computed using the joint coordinate system [12] between the calcaneus-leg (Cal-Leg), midfoot-calcaneus (Mid-Cal), metatarsus-midfoot (Met-Mid) and hallux-metatarsus (Hal-Met) segments. Gait events were defined from kinematic data [13] with data time normalised to 101 points.

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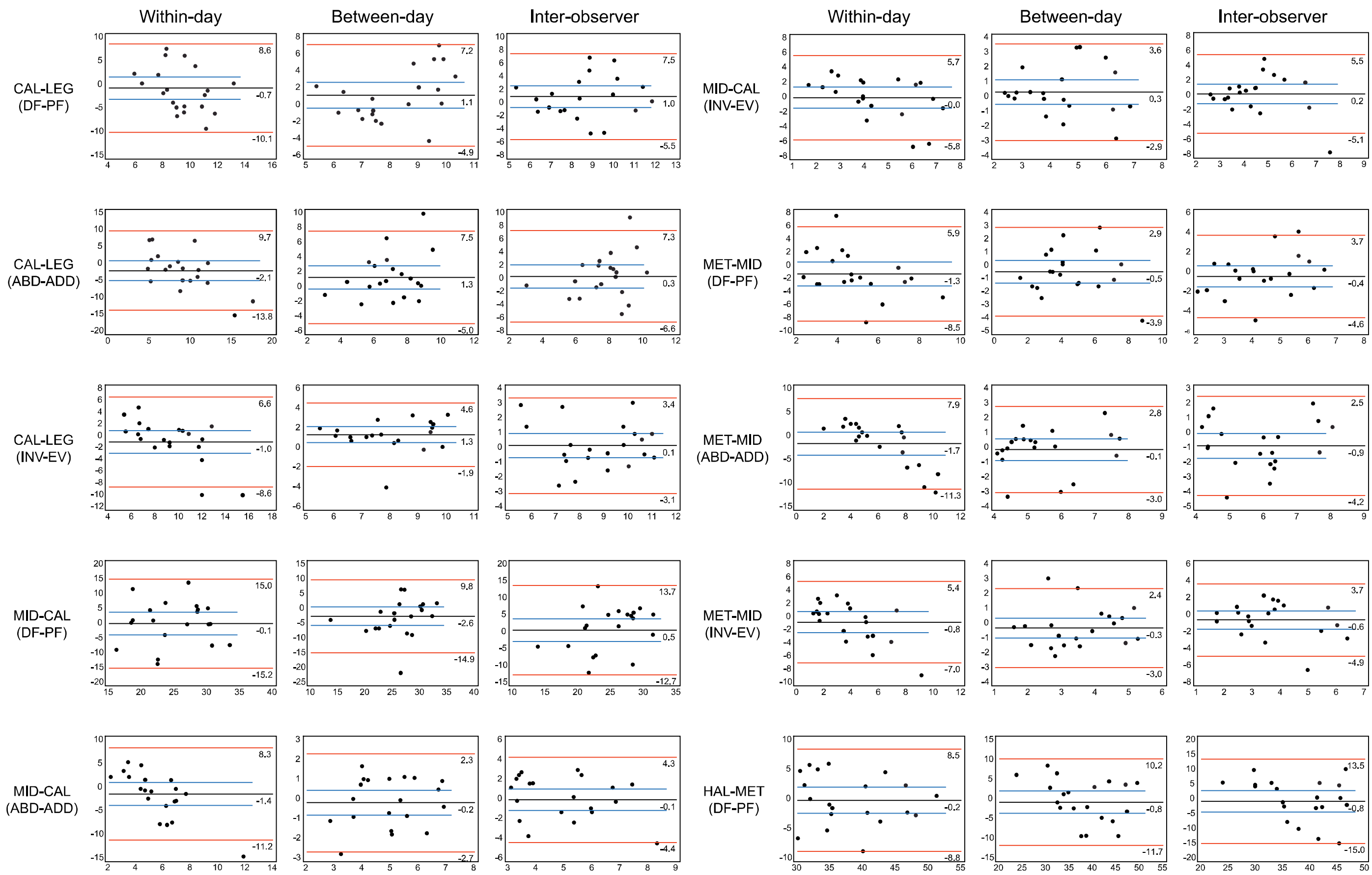


Fig. 1. Difference plots for joint range of motion between sessions (within-day, between day and inter-observer). The average of the two values for each subject is displayed on the x-axis, with the difference of the two values plotted on the y-axis. The mean difference (bias) between the ranges of motion of each session is displayed by the solid black line. Blue bars indicate the 95% confidence interval for the mean difference and red bars display the 95% limits of agreement (±1.96 SD). Corresponding values for the bias, 95% confidence interval and 95% limits of agreement are visible on the right hand side of each plot. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

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## Conflict of interest statement

The authors have no financial or personal relationships with other people or organisations that could inappropriately influence (bias) their work.

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