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Kinematic repeatability analyses of multi-segment foot motion in university-level ballet dancers

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INTRODUCTION

- Dancers are susceptible to overuse foot and ankle injuries, however there is a lack biomechanical studies examining foot mechanics to explain the causality of these injuries.
- Previous 3D multi-segment foot models (3DMFMs) applied in dance have only been assessed using a hindfoot, forefoot and hallux segment.[1-3]
- Nester et al. [4] found the largest degree of error found in 3DMFMs was where the navicular, 3 cuneiforms and all the metatarsals are analysed as a single segment.
- Dancers exhibit a large range of motion through this region of the foot[5] as compared to walking[6] and may exacerbate these errors.
- Dividing the foot into three segments; hindfoot, midfoot and forefoot may improve the repeatability of 3DMFMs for dance and would expand the current understanding of foot movement in dance, particularly regarding plantar flexion through the whole foot.

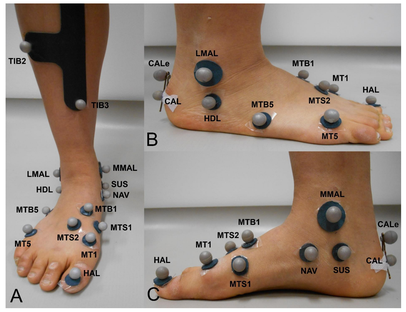

Figure 1 (A) Anterior view of the marker placement, (B) lateral view of the marker placement and (C) medial view of the marker placement

Figure 2. Anterior view of a dancer in (A) parallel stance, (B) demi-plié, (C) turnout stance and (D) turnout rise.

AIM

- To determine the intra and inter-assessor repeatability of a modified Rizzoli Foot Model (RFM) marker set-up[6] (Figure 1) by analysing ballet dancers during flex-point-flex movements and static ballet positions.

  Secondary aims were to develop a reliable marker set-up that would:

  1. Not impede joint movement.
  2. Minimise error due to skin movement artefact about the 1st metatarsophalangeal joint, midfoot and forefoot.

METHODS

- Modifications were made to the original RFM [6].
- Six female university-level ballet dancers (age 18.8 ± 0.8 years) performed the following trials in randomized order, natural stance, turnout plié and stance (Figure 2), and two dynamic trials; turnout rise and flex-pointé-flex movement.
- A twelve-camera motion capture system were used to track fourteen reflective markers and one triad on the following segments: tibia, entire foot, hindfoot, midfoot, forefoot and hallux.
- A repeated-measure design was used with each participant undergoing four data collection sessions; i.e. two sessions were conducted by each researcher over two consecutive days.
- Variability of the 3D segment rotations and planar angles were determined using intra-class correlation coefficients (ICC) for the intra and inter-assessor repeatability.

RESULTS

- Intra and inter-assessor reliability demonstrated excellent (ICC ≥ 0.75) repeatability for the 1st metatarsophalangeal joint in the sagittal plane.
- Intra-assessor reliability demonstrated excellent (ICC ≥ 0.75) repeatability during flex-point-flex across all inter-segmental angles except for the tibia-hindfoot and hindfoot-midfoot frontal planes.
- Inter-assessor repeatability ranged from poor to excellent (0.5 > ICC ≥ 0.75) for the 3D segment rotations.
- The most repeatable measure was the tibia-foot dorsiflexion/plantar flexion articulation whereas the least repeatable measure was the hindfoot-midfoot adduction/abduction articulation.
- The variation found in the inter-assessor results is likely due to inconsistencies in marker placement.

CONCLUSIONS

- This 3D dance specific multi-segment foot model provides insight into which kinematic measures can be reliably used to ascertain in vivo technical errors and/or biomechanical abnormalities in a dancer's foot motion.

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