Precision and Reliability of Foot Posture Assessment Using a Seven Segment Foot Model

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Introduction

Abnormal foot posture is believed to be associated with dysfunction during gait and, as a result, numerous lower extremity injuries. Individuals with high arches may be at greater risk of lateral and bony injuries, and individuals with low arches may have greater risk of medial and soft tissue injuries [1]. However, the relationship between static foot posture, dynamic foot function, and lower extremity injury continues to be poorly understood.

Although there are currently, multiple methods being used to quantify foot posture [1,2], the between- and/ or within- tester reliability of many of the measurements is low, limiting the clinical application [2]. Two measurements identified as having moderate-good reliability between- and/ or within- testers are the navicular index and arch angle [4].

Multi-segment foot models are used as a valid tool for measuring joint movement within the foot during various forms of gait [3]. They have not, however, been used to quantify static foot posture. A multi-segment foot model that can be used to precisely and reliably quantify static foot posture and dynamic foot function may advance the understanding of the relationship between foot posture and foot function [2].

The purpose of this study was to investigate the between- and within- tester precision and reliability of using a seven-segment foot model to quantify truncated foot length, navicular height, navicular index, and arch angle.

Methods

Participants

- 10 apparently healthy adults (ages 18-44)
- Exclusion criteria
  - Acute lower extremity injury within the last 3 months
  - Previous major orthopedic surgery of the involved limb
  - Significant lower limb edema
  - Lower extremity osteoarthritis or rheumatoid arthritis
  - Neuromuscular/ neurodegenerative disease

Procedures

- Tester 1 identified the landmarks associated with the foot model and placed reflective markers to identify the foot segments on the participant's right foot [3] (Figure 1)
- A 14-camera motion capture system recorded marker locations with the participant in a seated position
- All markers were removed and tester 2 repeated the procedure
- Each participant returned in one week for a second assessment

Data Analysis

- Within- and between- tester precision
  - Root mean square of the deviation between the positions of the anatomical landmarks in a trial and the landmarks mean position
- Within- and between- tester reliability
  - Intraclass correlation coefficients

Results

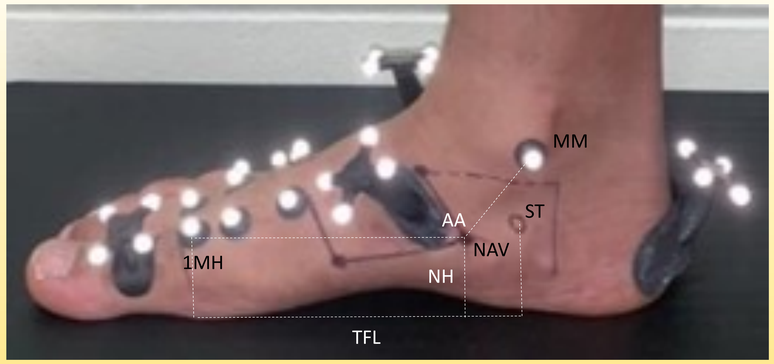

Figure 1. Anatomical landmarks identified on the right foot: Medial view

Landmarks: MM=Medial malleolus; ST=Sustentaculum tali; NAV=Navicular; 1MH = 1st Metatarsal head
Measurements: AA=Arch angle; NH=Navicular height; TFL=Truncated foot length; Navicular index = NH/TFL

Table 1. Within- and Between- Tester Precision

Variable	Within Tester	Between Tester
Truncated Foot Length (mm)	1.7	2.80
Navicular Height (mm)	1.45	2.40
Navicular Index	0.01	0.02
Arch Angle (°)	3.6	5.20

Table 2. Within- and Between- Tester Reliability ICC

Variable	Within Tester	Between Tester
Truncated Foot Length (mm)	0.81	0.62
Navicular Height (mm)	0.80	0.62
Navicular Index	0.76	0.71
Arch Angle (°)	0.25	0.30

Less than 0.5 = poor reliability, 0.5-0.75 = moderate reliability, 0.75-0.9 = good reliability, greater than 0.9 = excellent reliability [5]

Table3. Foot Posture Measurement, Mean and SD

Variable	T1D1*	T1D2	T2D1	T2D2
Truncated Foot Length (mm)	121.91 (6.86)	121.94 (5.76)	127.47 (7.11)	125.71 (6.69)
Navicular Height (mm)	52.69 (5.62)	52.65 (4.13)	56.83 (4.94)	57.45 (5.12)
Navicular Index	0.434 (0.055)	0.433 (0.040)	0.446 (0.038)	0.458 (0.047)
Arch Angle (°)	117.74 (7.86)	114.19 (12.83)	124.04 (6.12)	123.73 (6.39)

*T1: Tester 1, T2: Tester 2, D1: Day 1, D2: Day 2

Results and Discussion

Precision (Tables 1 & 3)

- Truncated foot length and navicular height precision within- testers was < 2 mm and between- testers < 3 mm (Table 1). The within- and between- tester precision for the navicular index, calculated from the navicular height and truncated foot length, was < 0.03.
- The least precise measure was the arch angle, with within- and between- precisions of < 4° and < 6°, respectively.

Reliability (Table 2 & 3)

- Within-tester reliability for truncated foot length, navicular height, and navicular index was good.
- Between-tester reliability for truncated foot length, navicular height, and navicular index was moderate.
- The within- and between- tester reliability for the arch angle was poor.

Using the seven-segment foot model, navicular index was precisely and reliably measured within- and between-testers. Arch angle, however, was not precisely or reliably measured. While the precision of the arch angle was as large as 5.2°, it was better than similar angular measures from a previous study [6].

The measurements for the navicular index suggest that the seven-segment foot model can be used to precisely and reliably quantify foot posture. Further research to investigate alternative methods to quantify arch angle and/or other measures of static foot posture, and the relationship between the static measures and dynamic foot function, is warranted.

Significance

- The seven-segment foot model can be used to precisely and reliably calculate the navicular index both within- and between- testers.
- A multi-segment foot model that can be used to precisely and reliably quantify foot posture during static and dynamic function may improve the understanding of the foot posture to function relationship.

Acknowledgments

This study was funded in part by a UW-Milwaukee SURF Student Research Grant Award.

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