Reliability of Navicular Drop Measurements in Standing and Sitting Positions

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Ji-Won Park, PT, PhD; Jong-Sung Chang, PT, PhD[1]; Ki-Seok Nam, PT, MS[1]

Department of Physical Therapy, College of Medical Science, Catholic University of Daegu; [1]Department of Physical Therapy, Yeungnam College of Science & Technology

Purpose: This study was designed to investigate inter-rater and intra-rater reliability of navicular drop measurements by clinicians in sitting and standing positions.

Methods: Fourteen subjects with pronated foot were recruited. Two physical therapists randomly assessed the same patients on different occasions but on the same day. Almost all patients were assessed on more than one day. The intra-rater and inter-rater reliability of navicular dropwas estimated by calculation of the intraclass correlation coefficient (ICC).

Results: The intra-rater reliability of navicular drop measurements ranged from 0.93 to 0.87, the inter-rater reliability from 0.98 to 0.70 with the patient in standing and sitting positions. These results showed good reliability for calculated variables. Intra-rater and inter-rater reliability of navicular drop in standing position was higher than those of sitting position.

Conclusion: Although inter-rater and intra-rater reliability of navicular drop in the sitting position was lower than in the standing position, measurement of navicular drop in the sitting position showed good reliability and was acceptable for patients who could not stand alone without assistance. We recommend that having the patient in the standing position is appropriate in navicular drop measurement.

Keywords: Navicular drop, Reliability, Pronated foot

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Corresponding author: Ki-Seok Nam, seokah@hanmail.net

I. Introduction

Flat foot (pes planus) is caused by mechanical uncoupling of the bones due to failure ofthe osteoligamentous complex that maintains the medial longitudinal arch (MLA) of the foot.[1,2] This complex involves the deltoid ligament, spring ligament, plantar fascia, plantar and talocalcaneal interosseous ligaments and the capsule of the talonavicular and naviculocuneiform joints maintaining normal relationships between the calcaneus, talus, navicular and medial cuneiform bones.[2-6]

The posterior tibial tendon may weaken and the talonavicular capsule, the tibionavicular ligament, the spring ligament, the long and short plantar ligaments and the plantar aponeurosis become stretched.[3,7,8] The shift in load from the lateral column to the medial column may cause the medial arch to flatten further.[1] That may cause the achilles tendon to exert a valgus moment, producing hill valgus and supination, abduction of the forefoot, and an increase in the talonavicular coverage angle.[9,10]

The highest point of the medial longitudinal arch in the sagittal plane is the tuberosity of the navicular bone.[11] So, direct measurement of the distance between this point and the supporting surface is one of the simplest methods of providing the clinician with quantifiable information regarding foot structure.[2,4,11]

Recent studies of flat foot measurements indicate that roentgen stereophotogrammetry is the most important contributor to the confirmation of a foot deformity.[12] But this process requires special equipment, and is therefore inappropriate for routine clinical assessment of foot posture.[13] Thus there is a need for simple clinical techniques to identify a flat foot.

A number of techniques for the clinical assessment of foot posture have been described in the literature, including the valgus index, footprint indexes, arch height, and frontal plane measurements of the rearfoot.[2,4,6,11,14-16] A navicular drop measurement is defined as the difference in height of the most prominent aspect of the navicular tuberosity when the subtalar joint is placed in neutral as compared with when the foot is positioned in a relaxed standing foot posture.[15,17,18] The validity and reliability of basic foot measurements are vital for charting the development of the foot and this study presents the intra-rater reliability of selected measures.[19-22] Although many of these techniques are widely used in clinical practice, their reliability and validity have not been established. Thus the purpose of this study was to investigate inter-rater and intra-rater reliability of navicular drop measurements done by clinicians with varied experience and according to patient position – sitting vs. standing.

II. Methods

1. Subjects

Fourteen subjects with a pronated foot were recruited. Participants without surgery of the lower extremity and without foot and ankle trauma within the 6 months preceding testing had more than 5° of rear foot angle while standing. They understood the purpose of this study and gave informed consent prior to investigations. The subjects of this study were 14 normal male (n=8) and female (n=6) adults in their twenties; their average age was 24.21±3.21 year.

2. Procedure

The two raters were a physical therapist with several years' experience of foot evaluation and treatment. Each subject was measured twice in succession by the same rater, with the retest on different days following the test to avoid the possibility of memorizing the measurements. Another rater measured navicular drop immediately after the first rater did so. The examiner was blinded to the results, examiner and participants' identities.

A vernier caliper (BahnTech, Japan) was used to measure the height of the navicular tuberosity (Figure 1). Each subject sat on a plate to ensure consistent foot placement. The subtalar joint neutral position (STJN) was determined by palpating the medial and lateral aspects of the talus with the thumb and index finger while the subject slowly inverted and everted his hindfoot until neither the medial nor lateral sides of the talar head were protruding or depressed.[23] The rater palpated the navicular tuberosity and marked the site with a pen in the STJN.

Figure 1. Vernier caliper used to measure height of navicular tuberosity.

To measure the navicular drop in the sitting position, the patient sat on a chair with his or her gluteal area except that the posterior of the thigh was used for facial weight bearing on foot. The subject was seated with both feet on the floor and hip flexed at 70°. The rater measured the height of the mark on the foot from the floor with the right foot in the STJN. The subject was asked to relax the foot into full weight bearing (subtalar joint resting position, STJR) and the height of the mark on the foot from the floor was then measured. The rater calculated the distance between the navicular height of the STJN and STJR as the navicular drop.

The subject was asked to stand with both feet on the floor. The rater measured the height of the mark with the right foot in the STJN and STJR that the subjectwas asked to stand on one leg flexed the contralateral leg. The rater calculated the navicular drop. The navicular drop was measured 3 times and the mean was calculated. The entire procedure was performed only for the left foot.

3. Statistical analysis

The data are presented as mean and standard deviations. To determine intra- and inter-rater reliability, the Intraclass Correlation Coefficient (ICC) analysis was used as an index of reliability.[24] All statistical analyses were performed using SPSS, version 12.0. Statistical significance was accepted for p-values <0.05.

III. Results

1. Intra-rater reliability and inter-rater reliability

Means and standard deviations for navicular drop measurements in standing and sitting positions are listed in Tables 1 and 2, respectively. Measurement of the navicular drop showed excellent intra-rater reliability with ICCs of 0.93 in standing position and good intra-rater reliability with ICCs of 0.87 in sitting position (Table 1). Results for the navicular drop showed excellent inter-rater reliability with ICCs of 0.98 in standing position and fair inter-rater reliability with ICCs of 0.70 in sitting position (Table 2). Intra-rater reliability and inter-rater reliability for navicular drop were higher for standing position than for sitting position.

Table 1. Intra-rater reliability of navicular drop

Position	Measurement			ICC	SEM
	1st	2nd	3rd		
stand	10.06±4.31	10.45±5.18	10.71±4.87	0.93	0.09
sit	9.43±4.94	8.75±3.72	9.28±3.95	0.87	0.12

ICC: Intraclass correlation coefficient, SEM: Standard error of measurement

Table 2. Inter-rater reliability of navicular drop

Position	Measurement		ICC	SEM
	Rater 1	Rater 2		
stand	10.41±4.51	9.74±4.07	0.98	0.08
sit	9.15±3.77	10.23±5.17	0.70	0.16

ICC: Intraclass correlation coefficient, SEM: Standard error of measurement

IV. Discussion

In the current study we investigated inter-rater and intra-rater reliability of navicular drop measurements by clinicians with the patients in sitting and standing position. Intra-rater and inter-rater reliabilityof navicular drop measurements for standing position were excellent and significant; for sitting position they were significant, but less exact smaller.

Many studies have reported the reliability of clinical measurements for foot navicular drop. These measurements have included footprint, navicular drift, navicular height, resting calcaneal stance position and forefoot to rearfoot measurements.[19,20,25,26] Navicular drop measurements have greater validity and reliability than the rest.[18,19] Several investigators have suggested that navicular drop measurements may be the most valid and reliable static clinical measure of foot deformity currently available to clinicians.[19,20,22,27] Shrader et al18 reported that navicular drop measurement has excellent intra-rater(ICC=0.90~0,99) and inter-rater(0.85~0.96) reliability. Evans et al[19] reported that navicular measurement have relatively good reliability in children when compared with other foot measurement methods.

This investigation focused on whether intra- and inter-rater reliability of navicular drop measurements for sitting and standing positions. The navicular drop measurement has higher reliability for the standing than the sitting position. The difference in reliability between sitting and standing position may be due to differences in weight-bearing distribution. In other words, in the standing position, the degree of navicular drop is almost fixed because of full weight-bearing; but with the patient in the sitting position, the degree of navicular drop isn't uniform because a degree of weight bearing is varied.

Generally, intra-rater reliability was higher than inter-rater reliability.[14,16,18] Intra-rater reliability may appear to be more clinically relevant, as it is unlikely that more than one practitioner will be required to take the same measurements from the same patient. Intra-rater reliability may have clinical implications, as it is unlikely that more than one rater will be required to take the same measurements from the same patient. But poor inter-rater reliability may be a problem with normative data.[21] In our study, like other studies, the intra-rater reliability was higher for the sitting position, but inter-rater reliability was higher than intra-rater reliability for the standing position. Therefore we suggest that navicular drop in the standing position is an acceptable tool for a pronated foot.

In our study, navicular drop measurements for different positions had high validity and reliability similar to previous studies. Therefore, navicular drop is a useful evaluation tool with clinical implications. But for higher intra- and inter-reliability, clinicians have sufficient duration and repeated numbers. And if clinicians or researchers want to attain excellent inter-rater reliability for navicular drop measurements, they should have sufficient practice.

Although inter-rater and intra-rater reliability of navicular drop measurements for sitting were lower than for standing, measurement of navicular drop in sitting had good reliability and was useful for patients who could not stand alone without assistance. Future research is now needed to determine navicular drop values for the sitting position using a larger sample size and evaluating relationships between navicular drop and rearfoot angle.

V. Conclusion

In the current study we investigated inter-rater and intra-rater reliability of navicular drop measurements by clinicians with varied experience according to patient position–standing vs. sitting. Our results showed that intra-rater and inter-rater reliability for navicular drop measurements were higher for standing than for sitting. Although inter-rater and intra-rater reliability for navicular drop measurements for sitting were lower thanfor standing, measurement of navicular drop for sitting had good reliability and is acceptable for patients who can not stand alone without assistance. We recommend the standing position as being most appropriate for navicular drop measurements.

Author Contributions

Research design: Park JW, Nam KS
Acquisition of data: Chang JS, Nam KS
Analysis and interpretation of data: Park JW, Nam KS
Drafting of the manuscript: Park JW, Nam KS, Chang JS
Researchsupervision: Nam KS

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