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Original Article

Reliability of novice and experienced physiotherapists using the normalized navicular height truncated and the foot posture index-6 for classifying static foot posture in adults

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Abstract. [Purpose] To investigate the reliability of novice and experienced physiotherapists using the normalized navicular height truncated and the foot posture index-6 for classifying foot posture in healthy adults. [Participants and Methods] Thirty asymptomatic adults participated in this study. After brief training, inter-rater reliability was performed by an expert and inexperienced rater (the novice physiotherapist). On the same day, both raters independently performed the normalized navicular height truncated and the foot posture index-6. For intra-rater reliability, the inexperienced rater repeated data collection on the 8th day after the first assessment. Intraclass correlation coefficients (ICCs) and Cohen's Weighted Kappa (K_w) were used for continuous and categorical data, respectively. [Results] The normalized navicular height truncated and the Rasch-converted foot posture index-6 scores demonstrated an excellent inter- and intra-rater reliability (ICCs=0.98–0.99). For classifying foot posture, the normalized navicular height truncated and the total foot posture index-6 scores represented more than 90% inter- and intra-rater agreement with K_w values ranging from 0.92–0.94, while each item of foot posture index-6 demonstrated inter- and intra-rater agreement ranging from substantial to almost perfect (K_w=0.71–0.94). [Conclusion] The normalized navicular height truncated and the foot posture index-6 are simple and reliable methods that can be used by the inexperienced rater.

Key words: Inexperienced examiner, Foot posture index-6, Normalized navicular height truncated

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INTRODUCTION

Because of its abnormal posture, a low- or high-arched foot is a predisposing factor of lower extremity injury and non-specific low back pain[1, 2]. Therefore, foot posture assessment and identification are crucial in routine practices to prescribe patients with tailored management plans. Consequently, simple and reliable diagnostic methods are particularly important to the health of these patients[1].

Of these methods, the normalised navicular height truncated (NNHt) and the foot posture index-6 (FPI-6) are often used in the practical classification of static foot postures[1]. The NNHt is a valid, non-invasive and uni-planar quantitative method that has a good to strong correlation with radiographic evaluation, which is a standard method[3] used by foot and ankle orthopaedic surgeons that is strongly associated with visual/physical examination[4]. When performed by an experienced rater, the

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NNHt has a moderate to excellent inter- and intra-rater reliability for different age groups[5]. However, there are few studies determining its reliability when a novice rater is used. The FPI-6 is an observational, tri-planar and semi-quantitative method that provides a more thorough overview of a foot's characteristics[6, 7]. The FPI-6 demonstrated a strong correlation with the Fastrak™ electromagnetic tracking system (EMT) for predicting foot types[6] and a good validity with a static lower-limb kinematic model[8]. For both experienced and inexperienced raters, the FPI-6 has a fair to almost perfect inter- and intra-rater reliability for different age groups[9, 10].

Although other studies have demonstrated their reliability and ease, no previous study has reported on the reliability of both the NNHt and the FPI-6 when performed by an inexperienced rater. Hence, as part of a larger study on the agreement between the NNHt and the FPI-6 on static foot posture classification in adults, the present study aimed to determine the reliability of the NNHt and the FPI-6 when performed on healthy adults by novice and experienced physiotherapists.

PARTICIPANTS AND METHODS

The sample size was calculated for the present reliability study using intraclass correlation coefficients (ICCs)[11] and Cohen's Kappa[12], and 30 participants were required. Thirty asymptomatic adults (9 males and 21 females) with an average age of 27.90 years (SD 4.8) and an average body mass index of 22.22 kg/m^2 (SD 1.8) were recruited, mainly from Khon Kaen University. Participants were excluded if they were pregnant, experienced ankle or foot pain or had a history of lower extremity injury within the previous 6 months, surgery and/or fracture of the spine and/or a lower extremity, neurological deficits such as stroke or spinal cord disorders and/or musculoskeletal disorders that might confound foot posture (e.g., spinal scoliosis, rheumatoid, gout, and SLE)[13]. Prior to data collection, all eligible participants signed a written informed consent form that was approved by the Khon Kaen University Ethics Committee in Human Research, Khon Kaen, Thailand (HE602301).

The NNHt was assessed following the studies of Scott et al.[14] and Murley et al[3]. The most prominent navicular tuberosity was palpated and marked with a removable ink pen. A card size of 7 × 12 cm^2 was used to record the perpendicular height of the navicular tuberosity (NH) from the supporting floor, and an Oxford dial calliper (precision=0.05 mm) was used to measure the NH. A steel ruler (mm) was used to measure the truncated foot length from the most medial end of the first metatarsophalangeal joint to the most posterior end of the heel[3]. The NNHt was calculated by dividing the NH by the truncated foot length that normalises the height of the medial longitudinal arch among individuals with different foot sizes[3]. A 3-trial measure was conducted, the ink was removed immediately after each trial, and the average value was then used for foot type classification. The foot postures were classified as follows: the NNHt score <0.17 categorised an extremely low-arched foot, 0.17–0.21 a low-arched foot, 0.22–0.31 a normal-arched foot, 0.32–0.35 a high-arched foot and >0.35 an extremely high-arched foot[3].

The FPI-6 was performed following the manual and clinical note of Redmond[7]. The FPI-6 consists of 6 items: talar head palpation, lateral malleoli curvature, calcaneal inversion/eversion, talonavicular bulging, height and congruence of the medial longitudinal arch, and abduction/adduction of the forefoot on the rearfoot. The rater palpated and observed the participant's foot, then scored each item on a 5-point Likert scale ranging from −2 to +2. The normal foot was represented as zero, while the low-arched foot was graded as a positive value, and the high-arched foot was rated as a negative value, giving the total score a range from −12 to +12. The total score of ≥10 represented an extremely low-arched foot, 6 to 9 a low-arched foot, 1 to 5 a normal-arched foot, −1 to −4 a high-arched foot and ≤−5 an extremely high-arched foot[7].

Following the suggestions of Saltzman et al.[15] and Redmond[7], this study trained the inexperienced rater prior to method usage and data collection. Two raters participated in this study: an established physiotherapist who specialises in foot/ankle assessment with intensive experience using the NNHt and the FPI-6 for foot posture classification (an expert) and a novice physiotherapist with one year extensive training in musculoskeletal examination but has no experience using the NNHt and the FPI-6 (a novice). After the expert briefly trained the novice, the expert supervised as the novice performed the NNHt and the FPI-6 on 30 individuals (not included in this study) with varied foot types[7, 15]. When the novice received the expert's approval, this supervision ended. The cumulative training time was 3 hours.

One week after the training session, an inter-rater study was conducted with the expert (rater 1) and the novice (rater 2). For each participant, the orders of the raters and the methods were randomly assigned using a simple random sample. On the same day, the raters conducted the methods independently with break of at least 10 minutes between each trial[13]. The raters were blind to each other and to their previous results. All participants were asked to walk 20 meters at their own pace and then stand on a stool in the double-stance relaxed position. Only the right foot was measured, because of the pooling data taken from both feet possibly producing a faulty result (e.g., type I error)[16]. An intra-rater study was conducted with the novice on the 8th day after the first assessment[17].

The data analysis was conducted using SPSS version 19 (IBM Corp, Armonk, NY, USA.) and Microsoft Excel 2016. The normal distribution of the data was assessed using the Shapiro-Wilk test. All demographic data were represented as mean, standard deviation (SD), number (n) or percentage (%). Inter- and intra-rater reliability for the NNHt and the Rasch-converted total FPI-6 scores[18] were analysed using ICCs with 95% confidence intervals. Cohen's Weighted Kappa (K_w) was used to determine the inter- and intra-rater agreements between each of the method and the individual FPI-6 items on different foot posture classifications. The ICCs were interpreted as follows: poor (less than 0.50), moderate (0.50–0.75), good

(0.75–0.90) and excellent (more than 0.90)[19]. Following Landis and Koch, the K_w values were interpreted as follows: fair (less than 0.40), moderate (0.41–0.60), substantial (0.61–0.80) and almost perfect (more than 0.80)[20]. The significance level was set at $p<0.05$.

RESULTS

Regardless of the method used or the examiner's experience, approximately 50% of the participants had a normal foot, approximately 40% had a low-arched foot and the remainder 10% had a high-arched foot (Table 1).

Inter- and intra-rater reliability estimations are given in Table 2 and Table 3, respectively. The NNHt and the Rasch-converted total FPI-6 scores demonstrated an excellent inter- and intra-rater reliability. For foot posture classification, the K_w values for the NNHt and the total raw FPI-6 scores indicated almost perfect inter- and intra-rater agreements, and the K_w values of each FPI-6 item gave agreements ranging from substantial to almost perfect.

Table 1. Foot type classification by the expert (rater 1) and the novice (rater 2) using a) the normalized navicular height truncated and b) the foot posture index-6

Rater 1	Rater 2					
	Extremely high arched	High arched	Normal arched	Low arched	Extremely low arched	Total
a)						
Extremely high arched						
High arched	1					1
Normal arched			15			15
Low arched			1	9		10
Extremely low arched				1	3	4
Total	1		16	10	3	30
b)						
Extremely high arched	3					3
High arched		1				1
Normal arched			13	1		14
Low arched			2	5		7
Extremely low arched				1	4	5
Total	3	1	15	7	4	30

Table 2. Inter-rater reliability of the NNHt and the FPI-6

Variables	Rater 1	Rater 2	K_w (95% CI)[a]	Observed agreement (%)	ICCs (95% CI)
	mean ± SD (min to max)	mean ± SD (min to max)			
NNHt	0.22 ± 0.05 (0.11–0.33)	0.22 ± 0.04 (0.10–0.36)	0.92 (0.87–0.94)	99.60	0.98[b] (0.95–0.99)
FPI-6	4.50 ± 4.64 (−7–11)	4.40 ± 4.67 (−7–11)	0.94 (0.91–0.96)	99.47	0.98[c] (0.96–0.99)
Agreement between rater 1 and rater 2 in each item of the FPI-6					
Item 1: talar head palpation			0.71 (0.68–0.75)	97.47	
Item 2: lateral malleoli curvature			0.76 (0.59–0.88)	98.40	
Item 3: calcaneal inversion/eversion			0.83 (0.78–0.84)	98.93	
Item 4: talonavicular bulging			0.73 (0.62–0.81)	98.13	
Item 5: height and congruence of medial longitudinal arch			0.94 (0.93–0.97)	99.60	
Item 6: abduction/adduction of the forefoot on the rearfoot			0.73 (0.67–0.85)	98.93	

NNHt: normalized navicular height truncated; FPI-6: foot posture index-6; min to max: minimum to maximum.
[a] Presented Weight Kappa with 95% confidence interval.
[b] Presented intraclass correlation coefficient [ICC (2,3)] with 95% confidence interval.
[c] Presented intraclass correlation coefficient [ICC (2,1)] with 95% confidence interval analyzed from the Rasch-converted total FPI-6 scores.

Table 3. Intra-rater reliability of the NNHt and the FPI-6

Variables	1st measurement	2nd measurement	K_w (95% CI)[a]	Observed agreement (%)	ICCs (95% CI)
	mean ± SD (min to max)	mean ± SD (min to max)			
NNHt	0.22 ± 0.04 (0.10–0.36)	0.22 ± 0.04 (0.10–0.34)	0.92 (0.91–0.97)	99.60	0.98[b] (0.95–0.99)
FPI-6	4.40 ± 4.67 (−7–11)	4.40 ± 4.68 (−7–11)	0.94 (0.94–0.95)	99.47	0.98[c] (0.96–0.99)
Agreement between test and retest of each the FPI-6 criteria					
Item 1: talar head palpation			0.81 (0.73–0.87)	98.53	
Item 2: lateral malleoli curvature			0.92 (0.76–0.97)	99.47	
Item 3: calcaneal inversion/eversion			0.82 (0.81–0.84)	98.80	
Item 4: talonavicular bulging			0.89 (0.85–0.91)	99.20	
Item 5: height and congruence of medial longitudinal arch			0.92 (0.88–0.94)	99.47	
Item 6: abduction/adduction of the forefoot on the rearfoot			0.71 (0.28–0.80)	98.80	

NNHt: normalized navicular height truncated; FPI-6: foot posture index-6; min to max: minimum to maximum.
[a] Presented Weight Kappa with 95% confidence interval.
[b] Presented intraclass correlation coefficient [ICC (3,3)] with 95% confidence interval.
[c] Presented intraclass correlation coefficient [ICC (3,1)] with 95% confidence interval analyzed from the Rasch-converted total FPI-6 scores.

DISCUSSION

This study demonstrates that, given a brief training period of 3 hours, a novice physiotherapist who has no experience in the clinical assessment of static foot postures can reliably use the NNHt and the FPI-6 for foot type classification in healthy young adults.

Regarding the NNHt, the result of this study is consistent with that of Xiong et al.[21], who demonstrated an excellent intra-rater reliability (ICC=0.98) when experts conducted the NNHt on asymptomatic adults. This reliability could be attributed to the similar characteristics of the participants (healthy adults aged 19–36 years) and the statistical analysis that used only data from the right foot. Our excellent inter- and intra-rater reliability result is higher than that of Evans et al.[22], who reported a good inter- and intra-rater reliability for the NNHt (ICCs 0.76–0.84) in adults aged 20–50 years. However, Evan et al. conducted their statistical analysis by pooling data from both feet, and this result should consequently be considered with caution[18]. Overall, reliability studies using the elderly and children as participants gave inconsistent results. Menz et al.[23] reported a moderate intra-rater reliability for the NNHt (ICC=0.64) in 31 participants aged 76–87 years. Likewise, Evans et al.[22] reported a moderate to good inter- and intra-rater reliability for the NNHt (ICCs 0.52–0.74) in children (4–6 years) and adolescents (8–15 years). These inconsistent results are likely due to age-related changes in foot structure and function. Therefore, different age groups may influence on the reliability of foot posture assessment. Notably, Hegazy et al.[5] reported an excellent inter- and intra-rater reliability (ICCs 0.98–0.99) for the NNHt in the right foot of 300 children aged 6 to 12 years.

To the best of our knowledge, this study is the first to determine the inter- and intra-rater agreement for the categorical data of the NNHt. Our study demonstrates an almost perfect inter- and intra-rater agreement for the NNHt for foot posture classification in healthy adults. Overall, the NNHt is a reliable and straightforward method for foot type classification. However, statistical analysis using the pooled data from both feet should not be further applied. The reliability of the NNHt in different age groups still needs to be addressed in a future study.

Regarding the FPI-6, our reported inter-rater reliability is slightly higher than that of McLaughlin et al.[9], who conducted a reliability study of an inexperienced rater with minimum training (1 hr) using the FPI-6 on young adults. They reported a good to excellent inter-rater reliability (ICCs 0.78–0.91) of the Rasch-converted FPI-6 score[9]. A similar finding was found in the categorical data for foot posture classification. McLaughlin et al.[9] also demonstrated a substantial inter-rater agreement for the total FPI-6 score, ranging from fair to substantial for individual items. In particular, they reported a fair agreement for item 2, the lateral malleoli curvature, and moderate agreement for item 6, abduction/adduction of the forefoot on the rearfoot. This is inconsistent with our results, and it may be due to our longer training session (3 hrs) and use of Redmond's clinical note[7] for scoring the individual items. Our reported reliability is also inconsistent with that of Aquino et al.[10], who demonstrated a moderate to good inter- and intra-rater reliability of the total raw FPI-6 score (ICCs 0.45–0.88) in healthy adults. For foot posture classification, this study reports a moderate to substantial intra- and inter-rater agreement for the total FPI-6 score and a fair to almost perfect inter- and intra-rater agreement for the individual items of the FPI-6. However, Aquino et al.[10] calculated the ICC for only the raw FPI-6 score (an ordinal scale), pooled data from both feet and

had an inconsistent test-retest period (7–15 days after the first assessment), and these factors possibly contributed to their inconsistent results. Moreover, in comparison with other previous studies[13, 17, 24], their study applied the raw FPI-6 score to the ICC analyses, which suggests that their findings should be determined with caution. Furthermore, the previous studies on different age groups gave varied reliabilities[13, 17, 24], indicating that clinical experience in FPI-6 usage, especially for children and the elderly, may be required.

Cumulatively, the FPI-6 is a simple and reliable method for foot type classification in adults. However, because of its inconsistent results, the reliability of the FPI-6 in children and the elderly necessitates further study. Before performing the FPI-6, it is recommended to consult the manual and the clinical note by Redmond[7]. Furthermore, statistical analysis using the pooled data from both feet[16] and the raw FPI-6 score[18] may not appropriate for ICC analyses. Additionally, given that different scores for each item can finally result in an equivalent total score, agreement analyses for the individual items of the FPI-6 should be considered.

There are some limitations in the present study that need to be acknowledged. The low frequencies of high-arched and extremely high-arched feet reported in this study might affect the reliability for asymptomatic adults. However, these findings are consistent with the previous studies, and this may result from a low variability of foot types in healthy adults. According to age and pathological condition may influence on the foot type, to confirm the excellent reliability and substantial to almost perfect agreement of the present findings, further study with participants in different age groups and specific disorders such as hypermobility syndrome, presence of bunions or callus formation needs to be determined. Finally, because most of our participants were female, the generalisation of the present results to males should be done with caution.

Overall, after the optimal training, the present findings demonstrated the excellent inter-rater reliability and substantial to almost perfect inter-rater agreement between the novice and the expert when performed the NNHt and the FPI-6 on the healthy adults. Furthermore, this study demonstrated the excellent test-retest reliability and high intra-rater agreement of the novice using the NNHt and the FPI-6. Therefore, our results support that the NNHt and the FPI-6 are simple and reliable clinical assessments for foot posture classification in adults.

Conflicts of interest

None.

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REFERENCES

1) Tong JW, Kong PW: Association between foot type and lower extremity injuries: systematic literature review with meta-analysis. J Orthop Sports Phys Ther, 2013, 43: 700–714. [Medline] [CrossRef]
2) O'Leary CB, Cahill CR, Robinson AW, et al.: A systematic review: the effects of podiatrical deviations on nonspecific chronic low back pain. J Back Musculoskeletal Rehabil, 2013, 26: 117–123. [Medline] [CrossRef]
3) Murley GS, Menz HB, Landorf KB: A protocol for classifying normal- and flat-arched foot posture for research studies using clinical and radiographic measurements. J Foot Ankle Res, 2009, 2: 22. [Medline] [CrossRef]
4) Chuckpaiwong B, Nunley JA 2nd, Queen RM: Correlation between static foot type measurements and clinical assessments. Foot Ankle Int, 2009, 30: 205–212. [Medline] [CrossRef]
5) Hegazy FA, Aboelnasr EA, El-Talawy HA, et al.: Reliability of normalised truncated navicular height in assessment of static foot posture in children (6–12 years). Eur J Physiother, 2017, 20: 122–125. [CrossRef]
6) Redmond AC, Crosbie J, Ouvrier RA: Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. Clin Biomech (Bristol, Avon), 2006, 21: 89–98. [Medline] [CrossRef]
7) Redmond AC: The Foot Posture Index: user guide and manual. 2005. https://studylib.net/doc/8078879/the-foot-posture-index (Accessed Jan. 1, 2019)
8) Buldt AK, Murley GS, Levinger P, et al.: Are clinical measures of foot posture and mobility associated with foot kinematics when walking? J Foot Ankle Res, 2015, 8: 63. [Medline] [CrossRef]
9) McLaughlin P, Vaughan B, Shanahan J, et al.: Inexperienced examiners and the Foot Posture Index: a reliability study. Man Ther, 2016, 26: 238–240. [Medline] [CrossRef]
10) Aquino MR, Avelar BS, Silva PL, et al.: Reliability of Foot Posture Index individual and total scores for adults and older adults. Musculoskelet Sci Pract, 2018, 36: 92–95. [Medline] [CrossRef]
11) Walter SD, Eliasziw M, Donner A: Sample size and optimal designs for reliability studies. Stat Med, 1998, 17: 101–110. [Medline] [CrossRef]
12) Sim J, Wright CC: The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther, 2005, 85: 257–268. [Medline]
13) Langley B, Cramp M, Morrison SC: Clinical measures of static foot posture do not agree. J Foot Ankle Res, 2016, 9: 45. [Medline] [CrossRef]
14) Scott G, Menz HB, Newcombe L: Age-related differences in foot structure and function. Gait Posture, 2007, 26: 68–75. [Medline] [CrossRef]
15) Saltzman CL, Nawoczenski DA, Talbot KD: Measurement of the medial longitudinal arch. Arch Phys Med Rehabil, 1995, 76: 45–49. [Medline] [CrossRef]
16) Menz HB: Two feet, or one person? Problems associated with statistical analysis of paired data in foot and ankle medicine. Foot, 2004, 14: 2–5. [CrossRef]
17) Cornwall MW, McPoil TG, Lebec M, et al.: Reliability of the modified Foot Posture Index. J Am Podiatr Med Assoc, 2008, 98: 7–13. [Medline] [CrossRef]

18) Keenan AM, Redmond AC, Horton M, et al.: The Foot Posture Index: Rasch analysis of a novel, foot-specific outcome measure. Arch Phys Med Rehabil, 2007, 88: 88–93. [Medline] [CrossRef]
19) Portney LG, Watkins MP: Foundations of clinical research: Applications to practice. 3rd ed. New Jersey: Prentice Hall Health, 2009.
20) Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics, 1977, 33: 159–174. [Medline] [CrossRef]
21) Xiong S, Goonetilleke RS, Witana CP, et al.: Foot arch characterization: a review, a new metric, and a comparison. J Am Podiatr Med Assoc, 2010, 100: 14–24. [Medline] [CrossRef]
22) Evans AM, Copper AW, Scharfbillig RW, et al.: Reliability of the foot posture index and traditional measures of foot position. J Am Podiatr Med Assoc, 2003, 93: 203–213. [Medline] [CrossRef]
23) Menz HB, Munteanu SE: Validity of 3 clinical techniques for the measurement of static foot posture in older people. J Orthop Sports Phys Ther, 2005, 35: 479–486. [Medline] [CrossRef]
24) Cain LE, Nicholson LL, Adams RD, et al.: Foot morphology and foot/ankle injury in indoor football. J Sci Med Sport, 2007, 10: 311–319. [Medline] [CrossRef]