An evaluation of musculoskeletal foot and ankle assessment measures

Lucy S Gates[1], Nigel K Arden[2, 3], Louise A McCulloch[4], Catherine J Bowen[1]

Abstract

Background: A variety of individual clinical musculoskeletal measures are used within foot and ankle assessment. However, if it is unclear which of these are appropriate for clinical and research use and if a comprehensive protocol exists.

Methods: A systematic search and review of the literature was undertaken to provide a summary of what is known about clinical foot and ankle assessment measures, to determine if these are associated with clinical outcomes of pain and function and to identify a comprehensive protocol if it exists.

Results: Following a process of article exclusion 49 articles were included within the final review. All types of evidence were considered to capture the maximum number of foot and ankle assessment methods currently available. Critical appraisal was carried out by two reviewers. The review identified a number of musculoskeletal foot and ankle assessment measures; however there is an absence of a comprehensive assessment protocol.

Conclusion: There is limited investigation for the association of musculoskeletal foot and ankle assessments to outcomes of pain and function and there is considerable variability in clinical reliability. The review highlights a requirement for the identification of an agreed set of standardised musculoskeletal foot and ankle assessments and further investigation to justify their use against clinically relevant outcomes.

Author details

1 Faculty of Health Sciences, Highfield, Building 45, University of Southampton, Southampton, SO17 1BJ, UK

2 NIHR Musculoskeletal Biomedical Research Unit, Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, Nuffield Orthopaedic Centre, University of Oxford, Oxford OX3 7LD, UK

3 MRC Lifecourse Epidemiology Unit, University of Southampton, Southampton, SO16 6YD, UK

4 Dorset HealthCare University NHS Foundation Trust, Sentinel House, Poole, Dorset, BH17 0RB, UK

Corresponding Author details
Lucy Gates
email: L.Gates@soton.ac.uk

Background

Clinical measures of the foot and ankle are an essential component of the assessment of foot function; facilitating treatment and providing a method for monitoring lower limb pathologies. Many individual physical techniques have been identified to measure characteristics of the foot [Buell et al., 1998; Nawoczenski et al., 1999; Hunt et al., 2000; Williams and McClay, 2000; Cornwall and McPoil, 2004; Cornwall et al., 2004; Redmond et al., 2006; Kim et al., 2008; McPoil et al., 2008; Hegedus et al., 2010], however it is unclear if a valid comprehensive clinical assessment protocol currently exists. Findings from a previous review of foot type classification methods have shown that despite the fact clinicians regularly perform static lower extremity measurements on their patients little research has been published to support their predictive ability to functional measures and injury [Razeghi and Bat,t 2002]. Whilst the review provided good insightful discussion into the concerns of using many static lower limb examinations to assess function and injury, it did not discuss the relationship of these measurements to pain. Also, additional assessments have since been introduced and it is unknown whether these assessment techniques are associated with clinical outcomes.

The main purpose of this review was to examine the literature and provide a summary of what is known about the clinical validity of clinical foot and ankle assessment measures and to determine if a comprehensive protocol exists. In order to effectively evaluate clinical assessments it is necessary to determine if they are associated with clinical outcomes. Additionally, it is essential to consider the importance of the clinical reliability of assessments.

Methods

A systematic search was completed

Keywords: **Foot, Ankle , Musculoskeletal, Assessment**

during November and December 2012. CINAHL and MEDLINE electronic databases were searched using EBSCO host portal. The main concepts of the search, search terms and synonyms were determined by members of a foot and ankle expert steering committee (n=19); formed as part of an international consensus study to define a foot and ankle assessment protocol (Gates et al., 2015). The Boolean operator 'AND' was used to combine key terms and the Boolean operator 'OR' was used to link synonyms. Limitations were applied to the searches in terms of language (English), age of and human participants.

Previous research has highlighted problems regarding the lack of National Health Medical Research Council level I – III-1 trials (systematic randomisation to pseudo-randomisation) [Bennell et al., 2007; NHMRC, 2009] in fields similar to this, which is also problematic in this area. Therefore no restrictions were placed on the type of study included. The review aimed to highlight all current clinical musculoskeletal foot and ankle assessments; therefore only clinical assessment measures were included within the search. Technical or laboratory based assessments were excluded. Criteria used to determine the articles included within the review can be seen in Table 1.

Table 1. Study inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles investigating/evaluating musculoskeletal foot and ankle assessment methods/measures	Patient Reported Outcome Measures/ self-reported assessments *
	Gait analysis*
	Measures using sophisticated equipment/ instrumentation (other than a goniometer or ruler) not routinely available within a clinical setting*
	Radiographic measures*
	Assessments specific to a pathology or disease or surgery*
	Non-MSK assessment (including vascular and neurological assessment)
	Foot pressure systems *

*Studies using the above techniques are excluded unless the technique is used for validation of a particular clinical foot and ankle assessment

One reviewer (LG) initially screened all titles and abstracts for potentially eligible articles and full text articles were obtained and included for critical review. Duplicate searches were removed and the results assessed for eligibility. A manual search of selected articles' reference lists was also completed. This hand screening process continued until all potential articles were exhausted. Two reviewers (LG and LM) independently reviewed and evaluated the quality of included studies. Full consensus was achieved for each study by discussion between the two reviewers; if no consensus could be met, a third reviewer (CB) served as a moderator.

The aim of the review was to identify all potential assessments, therefore all articles were deemed eligible. Due to the heterogeneity among studies with respect to procedures, design, and assessment type a critical narrative synthesis was most appropriate.

The following data were extracted from full-text articles: study reference, population and number of participants, type of measure, cross sectional validity against pain and function, longitudinal (predictive) validity, reliability where applicable. One reviewer (LG) extracted data from the included studies using a standardised proforma. Another reviewer (CB) independently cross checked extracted data.

Results

An initial search identified 2374 potential articles. Following the removal of articles based on title; those not specific to foot and ankle or assessment measures, abstract and full text content, 15 articles were retrieved. 34 additional articles were identified from hand searching of references. 49 articles were selected for inclusion in the review. Ten individual categories of foot and ankle assessment measures were identified: arch measures, navicular measures, ankle dorsiflexion range of motion, foot posture index, first metatarsal phalangeal joint measurements, rear foot measures, first ray measures, subtalar joint measures, forefoot measures, and manual supination test. Results including search processes were shared with an international foot and ankle expert steering committee via interactive web link (Gates et al., 2015).

Findings relevant to the outcomes of pain and function are discussed according to each individual assessment. The review did not identify evidence to support the existence of a comprehensive clinical musculoskeletal foot and ankle assessment protocol. The reliability of a measure is also an important consideration when identifying appropriate clinical assessments and it is essential for clinicians to be aware of the potential degree of measurement error for each. We have therefore provided a summary of evidence for the reliability of each assessment in appendix 1.

1. Arch measures

Clinical measures of arch height have shown significant associations to radiographic measures with correlations ranging from r = 0.52 - 0.93 [Saltzman et al., 1995; Williams and McClay, 2000; Menz and Munteanu, 2005; McPoil et al., 2008; Hegedus et al., 2010]. Studies have utilised a variety of populations including pathological [Hegedus et al., 2010], orthopaedic [Saltzman et al., 1995], older [Menz and Munteanu, 2005] and healthy [Williams and McClay, 2000; McPoil et al., 2008] and a range of examiners form orthopaedic surgeons to physical therapists with varying experience. Static longitudinal arch angle is reported to be positively correlated with dynamic longitudinal arch angle (r = 0.97) [McPoil and Cornwall, 2005], however no correlation was found between arch height and dynamic maximum eversion of the rear foot (r^2 = 0.06, P < 0.197) [Nigg et al., 1993]. Despite findings for the radiographic validity of clinical measures of arch height a study, limited to the older population, has shown no significant association (P > 0.05) between the arch index and disabling foot pain [Menz and Morris, 2005], balance and function [Menz et al., 2005] or falls [Menz et al., 2006].

2. Navicular measures

Clinical measurements of navicular height have shown to be strongly associated with radiographic navicular height (r = 0.79) [Menz and Munteanu, 2005] and associations have been reported to particular tests of balance and function, including maximum balance range (P<0.05), alternate step test (P < 0.01), sit to stand test and walking speed (P < 0.05) [Menz et al., 2005]. Results are limited to the older population and comprehensive inference is restricted by an absence of confidence intervals, which prevents further information of the likely range of possible values for the true effect. No significant association was found between navicular height and foot pain (P > 0.05) [Menz and Morris, 2005] or falls (P > 0.05) [Menz et al., 2006].

3. Ankle range of motion

Ankle flexibility has been shown to be associated with balance and functional tests in older people, including sway, maximum balance range, co-ordinated stability, alternate step test, sit-to-stand and walking speed (P < 0.01) [Menz et al., 2005]. It is also significantly different between fallers and non-fallers (P < 0.05) [Menz et al., 2006], with a reduction in flexibility in fallers. Ankle flexibility was not significantly associated with disabling foot pain (P > 0.05) [Menz and Morris, 2005].

4. First ray measures

No significant correlation was reported between manual assessment of first ray mobility and testing with a mechanical device (r = -0.25; P = 0.37) [Glasoe et al., 2002]. There was a significant difference between the clinical Eulji Medical Centre device and modified block test (P < 0.05) but not between the Eulji Medical Centre and Klaus device (P = 0.12) [Kim et al., 2008]. However the validity of the mechanical devices used in the evaluation of the clinical Eulji Medical Centre device is unclear. The review has identified no evidence to investigate the association of first ray measures to pain or function.

5. Subtalar joint measures

Subtalar joint range of movement is often represented by measures of the rear foot. Such measures often rely upon techniques which include the determination of subtalar joint neutral position. This is likely to have influenced the wide variation of reliability values across studies [Elveru et al., 1988; Smith-Oricchio and Harris, 1990; Picciano et al., 1993; Sell et al., 1994; McPoil and Cornwall, 1996; Menz and Keenan, 1997; Ogilvie et al., 1997] because, apart from difficulties ensuring isolation of the subtalar joint when measuring passive range of motion, measurements are largely based on subtalar joint neutral being a reference for zero; a method for measuring such has yet to be proven accurate or reliable between testers [Elveru et al., 1988; Picciano et al., 1993; Chen et al., 2008]. Additionally, determining subtalar joint neutral position is influenced by examiner experience; experienced examiners have been reported to positioned the rear foot into +1o of subtalar joint neutral position 41.3% of the time, compared to only 25% for untrained physiotherapy students [Pierrynowski et al., 1996]. The review failed to identify any evidence of investigation for the association of subtalar joint assessment to pain or function.

6. Foot Posture Index (FPI)

The FPI was the only foot and ankle assessment identified that was developed specifically as a composite tool via a systematic approach [Redmond et al., 2006]. Following a comprehensive process of internal construct validity testing the original FPI-8 item tool was reduced to 6 items [Redmond et al., 2008]. The FPI now consists of six validated, criterion-based observations of the foot of a subject standing in a relaxed position. Whilst the FPI provides a simple method of scoring the various features of foot posture into a single quantifiable result, it is limited in its clinical capacity to providing information only on standing foot posture.

Poor radiographic associations have been reported for the medial longitudinal arch congruence and ab/adduction of the forefoot versus radiographic measures (P = -0.28 - 0.42, respectively). Weak to moderate correlation was found for the original FPI- 8 against radiographic measures of navicular height (r = 0.59), calcaneal inclination angle (r = 0.36) and calcaneal first metatarsal angle (r = 0.42) [Menz and Munteanu, 2005]. However a significant association was reported between radiographic talonavicular angle and the talar head palpation component of the FPI (P = 0.02) [Scharfbillig et al., 2004]. During stance FPI-6 is reported to predict 64% of the variation of static ankle position, but only 41% of dynamic variation in foot position [Redmond et al., 2006]. Fair to moderate associations have been reported between FPI and certain parameters of dynamic foot function in individuals with and without patellofemoral pain (Barton et al., 2011).

No association has been found between FPI-6 and disabling foot pain (P > 0.05) [Menz and Morris, 2005], balance or functional tests in older people [Menz et al., 2005]. Neither was there any significant difference in FPI between groups of fallers and non-fallers (P > 0.05) [Menz et al., 2006].

7. Rear foot measures

A weak correlation has been reported between static calcaneal deviation and dynamic eversion during walking (r = 0.46, P = 0.048), although the estimate of true effect cannot be established due to the absence of reported confidence intervals [Hunt et al., 2000]. No statistically significant difference in rear foot motion was found between inverted and everted foot type groups (P > 0.05) [Cornwall and McPoil, 2004], suggesting changes in static rear foot measures are not associated with dynamic assessment. The review identified no evidence to show investigation for the association of rear foot measures and pain.

8. First metatarsal phalangeal joint measurements

Two active weight bearing measures of first metatarsal phalangeal joint range of movement were correlated with first metatarsal phalangeal joint motion during gait (r = 0.87 and 0.80). However correlation between passive weight bearing and non- weight bearing assessment of first metatarsal phalangeal joint range of movement and range of movement during gait was substantially lower (r = 0.61 and 0.67, respectively) [Nawoczenski et al., 1999]. Similarly it has been reported that there is no significant difference in first metatarsal phalangeal joint dorsiflexion between participants with normal versus abnormal passive hallux dorsiflexion during gait (P = 0.90) [Halstead and Redmond, 2006].

No significant association (P > 0.05) has been reported between first metatarsal phalangeal joint range of movement and disabling foot pain [Menz and Morris, 2005] and no significant difference was reported in first metatarsal phalangeal joint range of movement between fallers and non-fallers (P > 0.05) [Menz et al., 2006]. First metatarsal phalangeal joint range of movement was significantly associated with measures of balance such as sway (P < 0.05), maximum balance range (P < 0.01), coordinated stability (P < 0.05) and walking speed (P < 0.05) in older people [Menz et al., 2005].

9. Forefoot measures

The present review identified evidence with highly varied results for the reliability of forefoot measurement when taken using a goniometer (from poor to almost perfect) [Sell et al, 1994; Thoms and Rome, 1997; Cornwall et al., 2004; Halstead and Redmond, 2006]. Conclusions were difficult to draw due to the differences in study design, measurement techniques and examiner experience. There was however no evidence of investigation for the association of forefoot measures to pain or function.

10. Manual supination resistance test

The clinical manual supination test was poorly correlated to the value obtained from a mechanical supination device (r = 0.57, P < 0.0001) [Noakes and Payne, 2003]. The ability of the mechanical device to accurately measure the required force is unclear and there is no apparent evidence available to show its tested validity. The review identified no evidence to investigate the association of the clinical manual supination test to pain or function.

Discussion

This review has identified ten categories of clinical musculoskeletal foot and ankle measures, investigated over the last three decades. No evidence was identified of a comprehensive clinical musculoskeletal foot and ankle assessment protocol for use in either the clinical or research environment. Only independent foot and ankle assessment techniques have been identified and for many of these a lack of standardised measurement and study design has made comparison difficult. Many of the foot and ankle measures show considerable variability in clinical reliability and for many measures there is an absence of investigation for their association to clinically important outcomes such as pain and function.

The main objective of clinical foot and ankle assessment is to provide information to guide appropriate intervention. Interventions often aim to facilitate a reduction in pain and an increase in function, however this review has revealed limited investigation into the association between clinical musculoskeletal foot and ankle assessments and outcomes of pain and function [Menz et al., 2003; Menz and Morris, 2005; Menz and Munteanu, 2005; Menz et al., 2005; Menz et al., 2006]. Only ankle dorsiflexion, Foot Posture Index, arch, navicular and first metatarsal phalangeal joint measures have been investigated for an association with such outcomes.

Of these assessment measures, none have shown an association with foot pain. Navicular height, ankle dorsiflexion, first metatarsal phalangeal joint range of movement were associated with functional tests that include balance, stability, walking speed, sit to stand and stepping. Only ankle dorsiflexion was shown to be significantly different between fallers and non-fallers, with a reduction in flexibility in fallers. This suggests ankle flexibility may be an important consideration in the management of patients at risk of falls. Inferences of these associations was however limited to the older population. Further investigation of the identified measures across age groups and disease cohorts is recommended for the clinical justification of their use. It would be useful to investigate the association of pain and function, including falls, against the remaining measures. If assessments are not associated to the outcomes that treatment aims to facilitate, for instance pain and function then the value of the assessment is questionable.

Findings suggest that, of those clinical measures tested against “gold standard measures” for validity (FPI, first ray and first metatarsal phalangeal joint assessment, manual supination resistance test, arch and navicular measures); only FPI, navicular height and arch height have shown any degree of concurrent validity. It appears the FPI is the most rigorously tested clinical foot and ankle assessment tool available. Validation of the tool has been hindered by a limitation in gold standard comparative techniques, a problem that has also restricted the validation of other foot and ankle assessment measures. FPI has been shown to predict 41% of variance in mid-stance of walking [Redmond et al., 2006], however the large amount of unexplained variance does mean that FPI values cannot infer those structures during gait. When interpreting the findings of this review, several limitations need to be considered. Only English language articles published were included due to the lack of translation services. Literature was not searched from inception as the aim of the review was to identify current assessment methods. The authors believed duration of three decades would be suitable to expose investigation into the assessments currently used. Whilst the agreement between reviewers for the inclusion of articles was established via consensus meetings, the level of agreement was not quantified.

All relevant articles were considered, despite the methodological quality. This was to ensure the inclusion of all available clinical foot and ankle assessment measures. Whilst narrative synthesis of lower quality evidence makes comparison of findings more difficult to interpret, the authors believe it was important to identify all potential assessment methods and consider the limitations of all evidence rather than forfeit the inclusion of particular assessment methods.

Conclusion

It is clear that there is currently no comprehensive clinical protocol for the musculoskeletal assessment of the foot and ankle. A limited number of foot and ankle measures have shown an association with functional tests (navicular height, ankle flexibility, first metatarsal phalangeal joint range of movement); however no association has been shown between any of the foot and ankle measures identified and pain. For the majority of measures identified there is no evidence of investigation against outcomes of pain and function. The review highlights a requirement for the identification of a standardised set of clinical foot and ankle assessment measures and has provided evidence which has facilitated an informed process of consensus to achieve this. Further investigation will also be required to justify the use of such a set of measures according to clinically relevant outcomes such as pain and function.

Acknowledgements

We would like to acknowledge Arthritis Research UK, grant reference 19875, for providing fellowship funding to enable Lucy Gates to undertake her PhD.

Competing Interests

The author(s) declare that they have no competing interests

Authors' information

LG is undertaking a three year Arthritis Research UK training research fellowship at the University of Southampton

Authors Contributions

LG carried out carried out the literature search, data extraction, appraisal of literature and drafted the manuscript. CB remained available for arbitration during appraisal process and contributed to the conception, design and critical revisions of the manuscript. LM carried out the appraisal of literature. NA contributed to the conception and design and critical revisions of the manuscript. All authors read and approved the final manuscript.

References

Barton CJ, Levinger P, Crossley KM, Webster KE, Menz HB (2011) Relationships between the Foot Posture Index and foot kinematics during gait in individuals with and without patellofemoral pain syndrome. J Foot Ankle Res 4(10): 1-7

Bennell K, Bowles K, Payne C, Cicuttini F, Osborne R, Harris A, Hinman R (2007) Effects of laterally wedged insoles on symptoms and disease progression in medial knee osteoarthritis: a protocol for a randomised, double-blind, placebo controlled trial. BMC Musculoskelet Disord 8:96

Bennell K, Talbot R, Wajswelner H, Wassana T, Kelly D (1998) Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. Aust J Physiother 44:175-180

Brushøj C, Langberg H, Larsen K, Nielsen MB, Hölmich P (2007) Reliability and normative values of the foot line test: a technique to assess foot posture. J Orthop Sports Phys Ther 37:703-707

Buell T, Green D, Risser J (1998) Measurement of the first metatarsophalangeal joint range of motion. J Am Podiatr Med Assoc 78:439

Cornwall MW, Fishco WD, Mcpoil TG, Lane CR, O'donnell D, Hunt L (2004a) Reliability and Validity of Clinically Assessing First-Ray Mobility of the Foot. J Am Podiatr Med Assoc 94:470-476

Cornwall MW, Mcpoil TG (2004) Influence of rearfoot postural alignment on rearfoot motion during walking. Foot 14:133-138

Cornwall MW, Mcpoil TG, Fishco WD, Hunt L, Lane C, O'donnell D (2004) Reliability of visual measurement of forefoot alignment. Foot Ankle Int 25:745-748

Cornwall MW, McPoil TG, Lebec M, Vicenzino B, Wilson J (2008) Reliability of the Modified Foot Posture Index. J Am Podiatr Med Assoc 98(1): 7-13

Dahle L, Mueller M, Delitto A, Diamond J (1991) Visual Assessment of Foot Type and Relationship of Foot Type to lower Extremity Injury. J Orthop Sports Phys Ther 14:70-74

Elveru RA, Rothstein JM, Lamb RL (1988) Goniometric reliability in a clinical setting. Phys Ther 68:672-677

Evans AM, Copper AW, Scharfbillig RW, Scutter SD, Williams MT (2003) Reliability of the foot posture index and traditional measures of foot position. J Am Podiatr Med Assoc 93:203-213

Gates LS, Bowen CJ, Arden NK (2015). Clinical Measures of Musculoskeletal Foot and Ankle Assessment: An International Consensus Statement. Int J Health Sci 5(2): 91-105

Glasoe WM, Allen MK, Saltzman CL, Ludewig PM, Sublett SH (2002) Comparison of Two Methods Used to Assess First-Ray Mobility. Foot Ankle Int 23:248-252

Glasoe WM, Getsoian S, Myers M, Komnick M, Kolkebeck D, Oswald W, Liakos P (2005) Criterion-related validity of a clinical measure of dorsal first ray mobility. J Orthop Sports Phys Ther 35:589-593

Haight HJ, Dahm DL, Smith J, Krause DA (2005) Measuring standing hindfoot alignment: reliability of goniometric and visual measurements. Arch Phys Med Rehabil 86:571-575

Halstead J, Redmond AC (2006) Weight-bearing passive dorsiflexion of the hallux in standing is not related to hallux dorsiflexion during walking. J Orthop Sports Phys Ther 2006 36:550-556

Hegedus EJ, Cook C, Fiander C, Wright A (2010) Measures of arch height and their relationship to pain and dysfunction in people with lower limb impairments. Physiother Res Int 15:160-166

Hopson M, Mcpoil T, Cornwall M (1995) Motion of the first metatarsophalangeal joint. Reliability and validity of four measurement techniques. J Am Podiatr Med Assoc, 85:198-204

Hunt AE, Fahey AJ, Smith RM (2000) Static measures of calcaneal deviation and arch angle as predictors of rearfoot motion during walking. Aust J Physiother 46:9-16

Johnson SR, Gross MT (1997) Intraexaminer reliability, interexaminer reliability, and mean values for nine lower extremity skeletal measures in healthy Naval midshipmen. J Orthop Sports Phys Ther 25:253-263

Kim J-Y, Hwang SK, Lee KT, Young KW, Jung JS (2008) A Simpler Device for Measuring the Mobility of the First Ray of the Foot. Foot Ankle Int 29:213-218

Krause DA, Cloud BA, Forster LA, Schrank JA, Hollman JH (2011) Measurement of Ankle Dorsiflexion: A Comparison of Active and Passive Techniques in Multiple Positions. J Sport Rehabil, 20:333-344

Mcpoil TG, Cornwall MW (1996) The relationship between static lower extremity measurements and rearfoot motion during walking. J Orthop Sports Phys Ther 24:309-314

Mcpoil TG, Cornwall MW (2005) Use of the longitudinal arch angle to predict dynamic foot posture in walking. J Am Podiatr Med Assoc 95:114-120

Mcpoil TG, Cornwall MW, Vicenzino B, Teyhen DS, Molloy JM, Christie DS, Collins N (2008) Effect of using truncated versus total foot length to calculate the arch height ratio. Foot (Edinb) 18:220-227

Menz HB, Keenan A (1997) Reliability of two instruments in the measurement of closed chain subtalar joint positions. Foot 7:194-201

Menz HB, Morris ME (2005) Determinants of disabling foot pain in retirement village residents. J Am Podiatr Med Assoc 95:573-579

Menz HB, Morris ME, Lord SR (2005) Foot and ankle characteristics associated with impaired balance and functional ability in older people. J Gerontol A Biol Sci Med Sci 60:1546-1552

Menz HB, Morris ME, Lord SR (2006) Foot and ankle risk factors for falls in older people: a prospective study. J Gerontol A Biol Sci Med Sci 61A:866-870

Menz H, Munteanu S (2005) Validity of 3 Clinical Techniques for the Measurement of Static Foot Posture in Older People. J Orthop Sports Phys Ther 35:479-486

Menz HB, Tiedemann A, Kwan MM, Latt MD, Sherrington C, Lord SR (2003) Reliability of clinical tests of foot and ankle characteristics in older people. Journal J Am Podiatr Med Assoc 93:380-387

National Health and Medical Research Council (2009) NHMRC levels of evidence and grades for recommendations for developers of guidelines:1-24

Nawoczenski DA, Baumhauer JF, Umberger BR (1999) Relationship between clinical measurements and motion of the first metatarsophalangeal joint during gait. J Bone Joint Surg Am 81:370-376

Nigg BM, Cole GK, Nachbauer W (1993) Effects of arch height of the foot on angular motion of the lower extremities in running. J Biomech 26:909-916

Noakes H, Payne C (2003) The reliability of the manual supination resistance test. J Am Podiatr Med Assoc 93:185-189

Ogilvie SW, Rendall GC, Abboud RJ (1997) Reliability of open kinetic chain subtalar joint measurement. Foot 7:128-134

Picciano AM, Rowlands MS, Worrell T (1993) Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. J Orthop Sports Phys Ther 18:553-558

Pierrynowski M, Smith S, Mlynarczyk J (1996) Proficiency of Foot Care Specialists to Place the Rearfoot at Subtalar Neutral. J Am Podiatr Med Assoc 86:217-223

Razeghi M, Batt ME (2002) Foot type classification: a critical review of current methods. Gait and Posture 15: 282–291

Redmond AC, Crane YZ, Menz HB (2008) Normative values for the Foot Posture Index. J Foot & Ankle Res 1(6)

Redmond AC, Crosbie J, Ouvrier RA (2006) Development and validation of a novel rating system for scoring standing foot posture: the Foot Posture Index. Clin Biomech (Bristol, Avon) 21:89-98

Saltzman CL, Nawoczenski DA, Talbot KD (1995) Measurement of the medial longitudinal arch. Arch Phys Med Rehabil 76:45-49

Scharfbillig R, Evans AM, Copper AW, Williams M, Scutter S, Iasiello H, Redmond A (2004) Criterion validation of four criteria of the foot posture index. J Am Podiatr Med Assoc, 94:31-38

Sell K, Verity T, Worrell T, Pease B, Wigglesworth J (1994) Two Measurement Techniques for Assessing Subtalar Joint Position: A Reliability Study. J Orthop Sports Phys Ther, 19

Shirk C, Sandrey M, Erickson M (2006) Reliability of first ray position and mobility measurements in experienced and inexperienced examiners. J Athl Train 41:93-101

Smith-Oricchio K, Harris B (1990) Interrater Reliability of Subtalar Neutral, Calcaneal Inversion and Eversion. J Orthop Sports Phys Ther 12:10-15

Sobel E, Levitz S, Caselli M, Tran M, Lepore F, Lilja E, Sinaie M, Wain E (1999) Reevaluation of the Relaxed Calcaneal Stance Position Reliability and Normal Values in Children and Adults. J Am Podiatr Med Assoc 89:258-264

Somers DL, Hanson JA, Kedzierski CM, Nestor KL, Quinlivan KY (1997) The influence of experience on the reliability of goniometric and visual measurement of forefoot position. J Orthop Sports Phys Ther 25:192-202

Thoms V, Rome K (1997) Effect of subject position on the reliability of measurement of active ankle joint dorsiflexion. Foot 7:153-158

Van Gheluwe B, Kirby K, Roosen P, Phillips R (2002) Reliability and accuracy of biomechanical measurements of the lower extremities. J Am Podiatr Med Assoc 92:317–326

Vinicombe A, Raspovic A, Menz HB (2001) Reliability of navicular displacement measurement as a clinical indicator of foot posture. J Am Podiatr Med Assoc 91:262-268

Weightman A, Mann M, Sander L, Turley R (2004) Health Evidence Bulletins Wales: A systematic approach to identifying the evidence. Health Evidence Bulletins Wales

Weiner-Ogilvie S, Rome K (1998) The reliability of three techniques for measuring foot position. J Am Podiatr Med Assoc 88:381-6

Williams D, McClay I (2000) Measurements Used to Characterize the Foot and the Medial Longitudinal Arch: Reliability and Validity. Phys Ther 80:864-871

Youdas JW, Bogard CL, Suman VJ (1993) Reliability of goniometric measurements and visual estimates of ankle joint active range of motion obtained in a clinical setting. Arch Phys Med Rehabil 74:1113-111

Author & Year	Results	SEMs
Arch Measures		
Dahle et al (1991)	Inter-rater reliability between experienced clinicians (K=0 .72)	Not reported
Saltzman et al (1995)	*Intra- examiner reliability:* • Clinical anthropometric measures (ICC= 0.87-0.91) • Footprint measures (ICC= 0.96-0.99) • Radiographic (ICC ≥0.90) *Inter- examiner reliability*: • Clinical anthropometric measures (ICC= 0.74-0.79) • Footprint measures (ICC= 0.98-1.0) • Radiographic (ICC ≥0.90)	Not reported
Johnson & Gross (1997)	*Intra-examiner reliability:* • arch angle: ICC= 0.90 *Inter-examiner reliability:* • arch angle: ICC= 0.81	Not reported
Weiner-Ogilvie & Rome (1998)	*Inter- examiner reliability:* • Significant difference between examiners measurements of static arch height (P<0.05) *Intra- examiner reliability:* • No significant difference between each examiners measure of static arch height (P>0.05)	Not reported
Williams & McClay (2000)	*Intra- examiner reliability:* • For all measurements in 10% and 90% weight bearing (ICCs=0.804-0.982) • Dorsum height in 10% WB: ICCs= 0.940 and 0.961 and in 90% WB: ICCs=0.979 and 0.979 *Inter- examiner reliability:* • All measurements (ICCs= 0.480-0.924) • Dorsum height in 10% WB: ICC= 0.790 and in 90% WB: ICC=0.765 • Highest ICC was Navicular height divided by foot length in 10% WB (ICC=0.924). However this measure was lower in 90% WB (ICC=0.565). • Lowest ICC was first ray angle in 90% WB (ICC=0.480). • Dorsum height divided by foot length and dorsum height divided by truncated foot length had high ICC values of 0.811-0.854 and maintained consistent levels of reliability across both 10% and 90% WB	Not reported
McPoil & Cornwall (2005)	*Intra-examiner reliability:* • LAA (ICCs= 0.95 and 0.96) *Inter- examiner reliability:* • LAA: (ICC=0.67)	1.3°
McPoil et al (2008)	*Intra- examiner reliability:* • For all 3 measurements including total foot length, truncated foot length and dorsal arch height (ICCs=0.98-0.99)	0.03-0.05cm

Appendix 1. Summary table of reliability findings for foot and ankle assessments

	Inter- *examiner* reliability: • For all 3 measures (ICCs=0.98-0.99)	0.04-0.07cm
Hegedus et al (2010)	Intra- *examiner* reliability: • LAA measures (ICC=0.978) • mAR (ICC=0.961)	Not reported
Navicular Measures		
Picciano et al (1993)	Intra-examiner reliability: • Navicular drop (ICC=0.61 and 0.79)	2.57 and 1.92mm
	Inter-examiner reliability: • Navicular drop (ICC=0.57)	2.72mm
Sell et al (1994)	*Intra-examiner reliability:* • Navicular height in resting (ICC=0.95) • Navicular height in neutral position (ICCs= 0.92	Resting= 1.5mm Neutral= 1.9mm
	Inter-examiner reliability: • Navicular height in resting (ICC= 0.96) • Navicular height in neutral position (ICC=0.87)	Resting= 1.4mm Neutral= 2.3mm
McPoil & Cornwall (1996)	*Intra-examiner reliability:* • NH in relaxed stance: ICC=0.984 • NH in STJ neutral: ICC= 0.938	Not reported
Vinicombe et al (2001)	*Intra-examiner reliability:* • Navicular drop: ICCs=0.37-0.71 • Navicular Drift: ICCs= 0.30-0.62	Navicular Drop= 0.75-1.35mm Navicular Drift= 1.44-1.82mm
	Inter- examiner reliability: • Navicular Drop: ICCs= 0.72-0.75 • Navicular Drift: ICCs= 0.50-0.57	Navicular Drop= 1.17-1.27mm Navicular Drift= 2.05mm
Evans et al (2003)	*Intra-examiner reliability:* • Navicular Height (NH) In children: ICCs=0.47-63 • NH in adolescents: ICCs=0.75-0.81 • NH in adults: ICCs=0.80-0.85 • Navicular Drift (ND) in children: ICCs= 0.53-0.89 • ND in adolescents: ICCs= 0.63-0.71 • ND in adults: ICCs= 0.51-0.77	NH in children=1.0-1.77mm

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

	Inter-examiner reliability: • NH In children: ICCs=0.52 • NH in adolescents: ICCs=0.72 • NH in adults: ICCs=0.76 • ND in children: ICCs=0.55 • ND in adolescents: ICC=0.47 • ND in adults: ICC=0.46	NH in adolescents= 1.2-2.7m NH in adults= 1.0-1.3mm ND in children= 1.8-3.4mm ND in adolescent= 2.0-2.7mm ND in adults= 2.3-3.5mm
Menz et al (2003)	*Intra-examiner reliability:* • Navicular Height: ICC=0.64	Not reported
Brushøj et al (2007)	*The Foot Line Test* *Intra- examiner reliability:* • ICCs= 0.94-0.95	0.8-0.9mm
	Inter-rater reliability: • ICC=0.86 for left foot • ICC= 0.83 for right foot	1.3-1.4mm
Ankle Joint Dorsiflexion		
Youdas et al (1993)	*Intra-examiner reliability with goniometer:* • Active ankle dorsiflexion (ICCs= 0.64-0.98) *Inter-examiner reliability with goniometer:* • Active ankle dorsiflexion (ICC= 0.28) *Inter-examiner reliability with visual estimation:* • For active ankle dorsiflexion (ICC=0.34)	Not reported
McPoil & Cornwall (1996)	*Intra-examiner reliability with goniometer* • Ankle dorsiflexion with knee extended: ICC=0.976 • Ankle dorsiflexion with knee in 90o flexion: ICC=0.969	Not reported
Johnson & Gross (1997)	*Intra-examiner reliability with goniometer:* • ankle dorsiflexion with knee extended: ICC= 0.74 *Inter-examiner reliability with goniometer:* • ankle dorsiflexion with knee extended: ICC= 0.65	Not reported
Thoms & Rome (1997)	*Intra-tester reliability of goniometry for measurements of active ankle dorsiflexion using three subject position's:* Significant differences in active ankle dorsiflexion measurements were found between prone and sitting positions (P<0.05), supine and sitting (P<0.05) but not between prone and supine positions (P>0.05)	Not reported

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

Bennell et al (1998)	*Reliability of two methods of measuring weight bearing ankle dorsiflexion via lunge test:* *Intra-examiner reliability:* • Distance from wall measurement: ICC=0.98 and 0.97 • Angle between tibial shaft and vertical: ICC=0.98 and 0.98	Distance from wall=0.5 and 0.6cm Angle between tibial shaft and vertical= 1.1 and 1.1°
	Inter-examiner reliability: • Distance measurement: ICC= 0.99 • Angle measurement: ICC=0.97	Distance: 0.4cm Angle= 1.4°
Van Gheluwe et al (2002)	*Inter-examiner reliability (left and right foot) with goniometer:* • ankle dorsiflexion: 0.26 and 0.31	3.7 and 3.1 °
Menz et al (2003)	*Intra-examiner reliability:* • Ankle flexibility (modified lunge): ICC=0.87	Not reported
Krause et al (2011)	Reliability of ankle dorsiflexion ROM between five techniques: *Intra-examiner reliability:* • Passive ROM (PROM) at 0 degrees knee flexion: ICC= 0.70 and 0.76 • PROM at 90 degrees knee flexion: ICC= 0.83 and 0.78 • Active ROM (AROM) at 0 degrees knee flexion: ICC=0.82 and 0.81 • AROM at 90 degrees knee flexion:0.68 and 0.81 • Modified lunge: 0.88 and 0.89	PROM at 0 degrees knee flexion=2.3 and 2.5° PROM at 90 degrees knee flexion= 2.3 and 2.9 AROM at 0 degrees knee flexion=2.5 and 2.7° AROM at 90 degrees knee flexion= 2.4 and 2.1° Modified lunge= 2.3 and 2.2°
	Inter-examiner reliability: • PROM with 0 degrees knee flexion: ICC= 0.67 • PROM with knee at 90 degrees flexion: ICC= 0.79 • AROM with 0 degrees knee flexion: ICC= 0.62 • AROM with knee at 90 degrees flexion: ICC= 0.55 • Modified lunge: ICC=0.82	PROM at 0 degrees knee flexion= 2.62° PROM at 90 degrees knee flexion= 2.58° AROM at 0 degrees knee flexion= 3.70° AROM at 90 degrees knee flexion= 2.83° Modified lunge= 2.82

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

First Ray Measures		
McPoil & Cornwall (1996)	*Intra-examiner reliability:* • 1st ray position: K= 1.000	Not reported
Glasoe et al (2002)	*Intra-examiner reliability:* • manual first ray mobility examination: k=0.50 and 0.85	Not reported
	Inter-examiner reliability: • manual first ray mobility examination: k=0.16 and 0.09	
Cornwall et al (2004a)	*Inter-examiner reliability:* • Overall agreement among three clinicians assessing first ray mobility was 30%	Not reported
Glasoe et al (2005)	*Intra-examiner reliability:* • For mechanical device mobility (ICC= 0.98) • For ruler mobility (ICCs ≤ 0.06)	Mechanical device= 0.15mm Ruler=1.1mm
	Inter-examiner reliability: • For ruler (ICC=0.05)	Ruler=1.2mm
Shirk et al (2006)	*Intra-examiner reliability:* • For position of first ray (κ=0.27) 0.21 • For mobility of first ray (κ=0.26) 0.03	Not reported
	Inter-examiner reliability: • For position of first ray (κ=0.12) 0.03 • For mobility of first ray (κ=0.14) 0.02	
Kim et al (2008)	Reliability of a new tool (EMC) for measuring 1st ray mobility *Intra examiner reliability:* No statistically significant differences were found for each investigator (P values of 0.58, 0.93, 0.58 and 0.76, 0.79 0.80)	Not reported
	Inter examiner reliability: No significant differences for measurements among investigators wither (P=0.96)	
Subtalar Joint Measures		
Elveru et al (1988)	*Intra-examiner reliability:* • For measurements of the STJN position (ICC=0.77) • For unreferenced measurements of STJ PROM: inversion (ICC=0.74) and eversion (ICC=0.75) • For STJ PROM measurements referenced from STJN position: inversion (ICC=0.62) and eversion (ICC=0.59) • Ankle PROM: dorsiflexion (ICC=0.90) and dorsiflexion (ICC=0.86)	Not reported

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

	Inter-tester reliability: • For measurements of the STJN position (ICC=0.25) • For unreferenced measurements of STJ PROM for inversion (ICC=0.32) and eversion (ICC=0.17). • For STJ PROM measurements referenced form STJN position: inversion (ICC=0.15) and eversion (ICC=0.12) • Ankle PROM: dorsiflexion (ICC=0.50) and dorsiflexion (ICC=0.72).	
Smith-Oricchio & Harris (1990)	Rear foot frontal plane measures are used to represent STJ within article: *Inter-examiner reliability:* • Calcaneal inversion motion (ICC= 0.42) and eversion motion (0.25) • Palpated STJN (ICC= 0.60) • Calcaneal position in bilateral resting stance (ICC= 0.91) • Calcaneal position in unilateral resting stance (ICCs=0.75)	Not reported
Picciano et al (1993)	*Intra-examiner reliability:* • Open kinetic chain STJN (ICC=0.06-0.27) • Closed kinetic chain STJN (ICC= 0.14-0.18)	Open kinetic chain STJN= 1.81-2.29° Closed kinetic chain STJN= 2.40-2.46°
	Inter-examiner reliability between inexperienced examiners: • Open kinetic chain STJN (ICC= of 0.00) • Closed kinetic chain STJN (ICC= 0.15)	Open kinetic chain STJN= 2.51° Closed kinetic chain STJN= 2.43°
Sell et al (1994)	STJ position represented by standing calcaneal and navicular height measurements *Intra-examiner reliability:* • For standing calcaneal measurements and navicular height in resting (ICC= 0.85 and 0.95) • For standing calcaneal measurements and navicular height in neutral position (ICCs= 0.85 and 0.92).	Resting calcaneal and navicular height= 1° and 1.5mm, respectively Neutral calcaneal and navicular height= 1.9mm
	Inter-examiner reliability: • For calcaneal measurement and navicular height in resting (ICC= 0.68 and 0.96) • For standing calcaneal measurements and navicular height in neutral position (ICCs= 0.79 and 0.87).	Resting calcaneal and navicular height= 1.8° and 1.4mm, respectively Neutral calcaneal and navicular height= 1.3° and 2.3mm

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

McPoil & Cornwall (1996)	*Intra-examiner reliability:* • STJ inversion: ICC=0.947 • STJ eversion: ICC= 0.964 • STJ neutral position: ICC= 0.97	Not reported
Pierrynowski et al (1996)	Experienced foot care specialists positioned the rear foot into +1° of the represented STJN position 41.3% of the time, whereas untrained physiotherapy students positioned it the same 25.0% of the time.	Not reported
Ogilvie et al (1997)	*Intra-examiner reliability:* • All positions (ICCs=0.80-0.97)	For % of eversion from total ROM only= 1.53 and 2.23%
	Inter-examiner reliability: • Sagittal and transverse plane in maximum pronation, supination and neutral were fair-good (ICCs= 0.71-0.88). • In the frontal plane, reliability was good for neutral and supinated position (ICCs= 0.86 and 0.84, respectively) and slightly lower for pronation (ICC= 0.79). • Palpated neutral position was significantly different from the calculated STJN root method (P=0.001)	
Menz & Keenan (1997)	*Intra-examiner correlation:* • Neutral calcaneal stance position (NCSP) with an angle finder: r=0.811 • NCSP with digital goniometer: r= 0.168 • Resting calcaneal stance position (RCSP) with angle finder: r= 0.354 • RCSP with digital goniometer: r= 0.197	NCSP with angle finder=3.77° NCSP with digital goniometer= 8.47 ° RCSP with angle finder= 6.27° RCSP with digital goniometer= 6.42 °
	Inter-examiner correlations: • NCSP with an angle finder: r=0.367-0.639 • NCSP with digital goniometer: r=0.558-0.561 • RCSP with angle finder: r=0.742 • RCSP with digital goniometer: r=0.617	NCSP with angle finder= 6.52° NCSP with digital goniometer= 6.16 ° RCSP with angle finder= 4.32° RCSP with digital goniometer= 4.44 °
Foot Posture Index		
Evans et al (2003)	*FP-8 Intra-examiner reliability:* • In children: ICCs=0.78-0.83 • Adolescents: ICCs=0.79-0.89 • Adults: ICCs=0.72-86	children: 1.1-1.7 adolescents= 1.0-1.3

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

	FP-8 Inter-examiner reliability: • In children (ICCs=0.62) • adolescents (ICCs=0.74) • adults (ICCs=0.58)	adults= 1.1-1.5
Cornwall et al (2008)	*FPI-6 Intra-examiner reliability*: • ICCs= 0.928, 0.928 and 0.937 *FPI-6 Inter-examiner reliability:* • ICCs= 0.566	Not reported
Rear foot Measures		
Johnson & Gross (1997)	*Intra-examiner reliability:* • rear foot angle (calcaneus to leg with goniometer): ICC= 0.88 *Inter-examiner reliability:* • rear foot angle (calcaneus to leg with goniometer): ICC= 0.86	Not reported
Sobel et al (1999)	*Intra-examiner reliability:* • For relaxed calcaneal stance position with a goniometer (ICCs=0.61-0.90) *Inter- examiner reliability:* • No significant difference between three examiners in the measurement of relaxed calcaneal stance position with a goniometer (P>0.05)	Non reported
Van Gheluwe et al (2002)	*Inter-examiner reliability (left and right foot):* • relaxed calcaneal stance: 0.61 and 0.62 • neutral calcaneal stance: 0.31 and 0.21	Left and right foot: relaxed calcaneal stance= 2.6 and 2.4° neutral calcaneal stance= 2.3 and 3.4°
Evans et al (2003)	*Intra-examiner reliability:* • Resting Calcaneal Stance Position (RCSP) in children: ICCs=0.52-0.79 • RCSP in adolescents: ICCs=0.51-0.85 • RCSP in adults: ICCs=0.17-0.70 • Neutral Calcaneal Stance Position (NCSP) in children: ICCs= 0.07-0.20 • NCSP in adolescents: ICCs= 0.10-0.91 • NCSP in adults: ICCs= 0.32-0.72 *Inter-examiner reliability:* • RCSP In children: ICCs= 0.54 • RCSP in adolescents: ICCs= 0.55 • RCSP in adults: ICCs= 0.25 • NCSP in children: ICCs= 0.02 • NCSP in adolescents: ICC= 0.12 • NCSP in adults: ICC= 0.33	RCSP in children=1.4-1.6° RCSP in adolescents= 0.9-1.8° RCSP in adults= 1.2-6.2° NCSP in children= 0.5-2.1° NCSP in adolescents= 0.2-1.3° NCSP in adults= 1.1-1.6°

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

Cornwall & McPoil (2004)	*Intra-examiner reliability*: • rear foot angle in resting stance position (ICC= 0.950)	Non reported
Haight et al (2005)	*Intra-examiner reliability*: • For visual standing tibio-calcaneal angle (ICC=0.88-0.94) • For goniometric standing tibio-calcaneal angle (ICC= 0.80-0.93) *Inter-examiner reliability:* • For visual standing tibio-calcaneal angle (ICC=0.56-0.65) • For goniometric standing tibio-calcaneal angle (ICC= 0.50-0.75)	Not reported
First Metatarsal Phalangeal Joint Measures		
Hopson et al (1995)	*Intra-examiner reliability (for static assessment of 1st MTPJ extension ROM with a goniometer):* • Non weight-bearing (1): 0.951 • Non weight-bearing (2): 0.906 • Partial weight-bearing: 0.948 • Weight-bearing step length: 0.976 Significant differences in mean values for each static method (P<0.05).	Non weight-bearing (1)= 1.26° Non weight-bearing (2)= 1.38° Partial weight-bearing= 0.80° Weight-bearing step length= 1.44°
McPoil & Cornwall (1996)	*Intra-examiner reliability with goniometer:* • 1st MTP extension: ICC= 0.986	Non reported
Forefoot Measures		
McPoil & Cornwall (1996)	*Intra-examiner reliability using goniometer:* • Forefoot position: K= 0.760	Not reported
Somers et al (1997)	*Intra-examiner reliability using goniometer:* • Forefoot position measured by experienced examiner (ICCs= 0.78 and 0.08*) • Forefoot position measured by in-experienced examiners (ICCs= 0.65 and 0.16*) *Intra-examiner reliability using visual estimation:* • Forefoot position measured by experienced examiner (ICCs= 0.76 and 0.51) • Forefoot position measured by in-experienced examiners (ICCs= 0.53 and 0.57) *Inter-examiner reliability using goniometer:* • Forefoot position measured by experienced examiner (ICC= 0.38*) • Forefoot position measured by in-experienced examiner (ICC= 0.42*)	Experienced examiners using a goniometer= 0.86° and 1.04° Inexperienced examiners using a goniometer= 1.06° and 2.19° Experienced examiners using visual estimation=1.35° and 1.70° Inexperienced examiners using visual estimation= 1.28° and 1.05°

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments

	Inter-examiner reliability using visual estimation: • Forefoot position measured by experienced examiner (ICC= 0.81) • Forefoot position measured by in-experienced examiner (ICC= 0.72) *Denotes potentially invalid ICC values	
Van Gheluwe et al (2002)	*Inter-examiner reliability (left and right foot) with goniometer:* • forefoot varus: 0.61 and 0.62	• forefoot varus: 3.4 and 3.1 °
Cornwall et al (2004)	Out of three clinicians (one podiatrist, 2 physical therapists), with varying degrees of experience, only the experienced physiotherapists were found to have a statistically significant agreement with each other, with an agreement of 61.7% with a chance agreement of 41.7% (KAPPA=.342, p<.05).	Not reported
Manual Supination		
Noakes & Payne (2003)	*Intra-examiner reliability:* • For experienced clinicians (ICCs=0.82 and 0.78) • For less experience clinicians (ICCs=0.56 and 0.62) *Inter-examiner reliability*: • ICC=0.89	Not reported

Appendix 1. Cont. Summary table of reliability findings for foot and ankle assessments