A "hands on" approach to acute lateral ankle sprains: how to resolve arthrokinematic restrictions

Professor Eamonn Delahunt

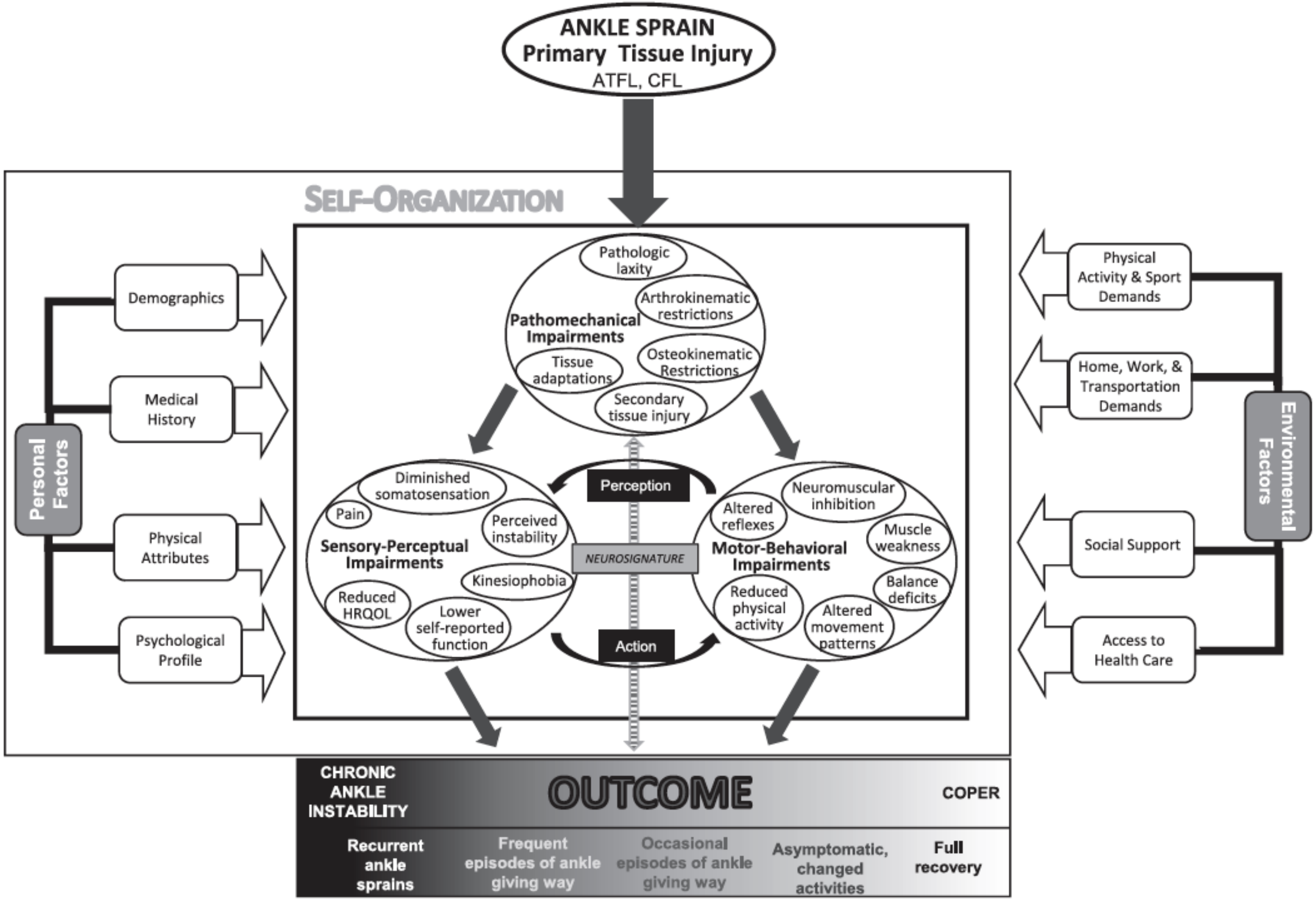

Figure 1. The updated model of chronic ankle instability (CAI). The outcome is determined at least 12 months after the initial ankle sprain. Abbreviations: ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; HRQOL, health-related quality of life.

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Original paper

Dorsiflexion range of motion significantly influences dynamic balance

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Abstract

The purpose of this study was to examine the relationships between dorsiflexion range of motion on the weight-bearing lunge test (WBLT) and normalized reach distance in three directions on the Star Excursion Balance Test (SEBT). Thirty-five healthy adults (14 males, 21 females, age: 25.9 ± 6.7 years, height: 166.7 ± 22.9 cm, weight: 76.7 ± 22.8 kg) participated. All subjects performed three trials of maximum lower extremity reach in the anterior, posteromedial, and posterolateral directions of the SEBT on each limb to assess dynamic balance. Subjects performed three trials of the WBLT to measure maximum dorsiflexion range of motion. Dependent variables included the means of the SEBT normalized reach distances in the anterior, posteromedial, and posterolateral directions and the mean of the WBLT. Only the anterior direction (mean: 79.0 ± 5.8%) of the SEBT was significantly related to the WBLT (mean: 11.9 ± 2.7 cm), $r = 0.53$ ($p = 0.001$). The r^2 for this simple linear regression was 0.28, indicating that the WBLT explained 28% of the variance in the anterior normalized reach distance. The WBLT explained a significant proportion of the variance within the anterior reach distance signifying this direction of the SEBT may be a good clinical test to assess the effects of dorsiflexion range of motion restrictions on dynamic balance.

Keywords: Postural control; Lower extremity injury; Ankle

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1. Introduction

Dorsiflexion range of motion (DROM) deficits have been identified following ankle sprain, Achilles' tendinopathy, and an array of other foot and ankle injuries.[1–3] Additionally, decreased DROM has been detected during walking in individuals with diagnosed ankle arthrosis[4] and jogging in those with chronic ankle instability.[5] Static stretching of the triceps surae complex[1] and posterior talar glide joint mobilization techniques[3,6] have been previously investigated and appear to successfully address this deficit. Despite these findings, limited evidence exists regarding the relationship between DROM and performance on clinical assessments of dynamic postural control such as the Star Excursion Balance Test (SEBT). The SEBT is a battery of lower extremity maximal reach tests while the contra-lateral limb attempts to maintain single-limb balance.[7] In this test, reaching distance serves as a measure of performance. Shorter reach distances are typically associated with mechanical or sensorimotor system constraint. Hertel[8] recommends using the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions versus the traditional 8 directions to avoid capturing redundant information. Identifying clinical tests to evaluate the effects of DROM restrictions are important for the assessment and rehabilitation of foot and ankle injuries. Therefore, the objective of this study was to examine the relationships between DROM on the weight-bearing lunge test (WBLT) and the normalized SEBT reach distance in ANT, PM, and PL directions.

2. Methods

Thirty-five healthy adults (14 males, 21 females, age: 25.9 ± 6.7 years, height: 166.7 ± 22.9 cm, weight: 76.7 ± 22.8 kg) participated in this cross-sectional study. All subjects had no history of lower extremity injury in the past 6 months, no self-reported disability in the foot and ankle, and

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Original research

Dorsiflexion and dynamic postural control deficits are present in those with chronic ankle instability

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Abstract

Objectives: To determine if differences in weight-bearing ankle dorsiflexion range of motion (DFROM) and Star Excursion Balance Test (SEBT) reach distances were present between participants with chronic ankle instability (CAI) and healthy individuals. A secondary objective was to re-examine the relationship between these measures in participants with and without CAI.
Design: Case–control.
Methods: Thirty participants with CAI were matched to 30 healthy participants. All participants performed maximum reach in the anterior, posteromedial and posterolateral directions of the SEBT; as well as, the Weight-Bearing Lunge Test (WBLT) to measure DFROM. Dependent variables included maximal DFROM (cm) and normalized SEBT reach distances (%). Independent *t*-tests were used for group comparisons (a priori $p \leq 0.05$). Simple-linear regression examined the relationship between the WBLT and each SEBT direction.
Results: Significant differences were detected between groups for the WBLT (CAI: 10.73 ± 3.44 cm, healthy: 12.47 ± 2.51 cm; $p = 0.03$) and anterior reach distance (CAI: 76.05 ± 6.25%, healthy: 80.12 ± 5.88%; $p = 0.01$). No differences were identified in posteromedial or posterolateral ($ps > 0.70$) reach. The WBLT had a significant moderate correlation to anterior reach in both groups ($ps < 0.05$) but was not significantly correlated to posteromedial or posterolateral reach distance ($ps > 0.70$).
Conclusions: The results indicate that participants with CAI demonstrated less DFROM and anterior SEBT reach distance compared to health controls. Additionally, both groups demonstrated similar correlations between WBLT and SEBT performance. These findings suggest that participants with CAI have alterations in ankle motion which may negatively influence dynamic postural control; however, the relationship between WBLT and SEBT performance is consistent in those with and without CAI.

Keywords: Ankle sprain; Joint instability; Rehabilitation

1. Introduction

Up to 70% of individuals who sustain a single lateral ankle sprain experience residual symptoms including pain and swelling, recurrent episodes of ankle instability, and repetitive ankle sprains which are the hallmark characteristics of chronic ankle instability (CAI).[1,2] Although ankle sprains are often considered innocuous injuries, CAI has been associated with long-term consequences such as post-traumatic ankle osteoarthritis and decreased health-related quality of life.[3,4] A well-documented contributing factor for CAI is deficits in postural control.[5,6] Postural control deficits have been particularly evident in those with CAI when evaluated using dynamic assessment techniques which examine the capacity to maintain stability within the boundaries of the base of support during functional activities.[6,7] Therefore, CAI is a common health condition in physically active individuals and gaining further insight into how dynamic postural control deficits contribute to this multi-faceted health condition may be useful in developing meaningful intervention strategies.

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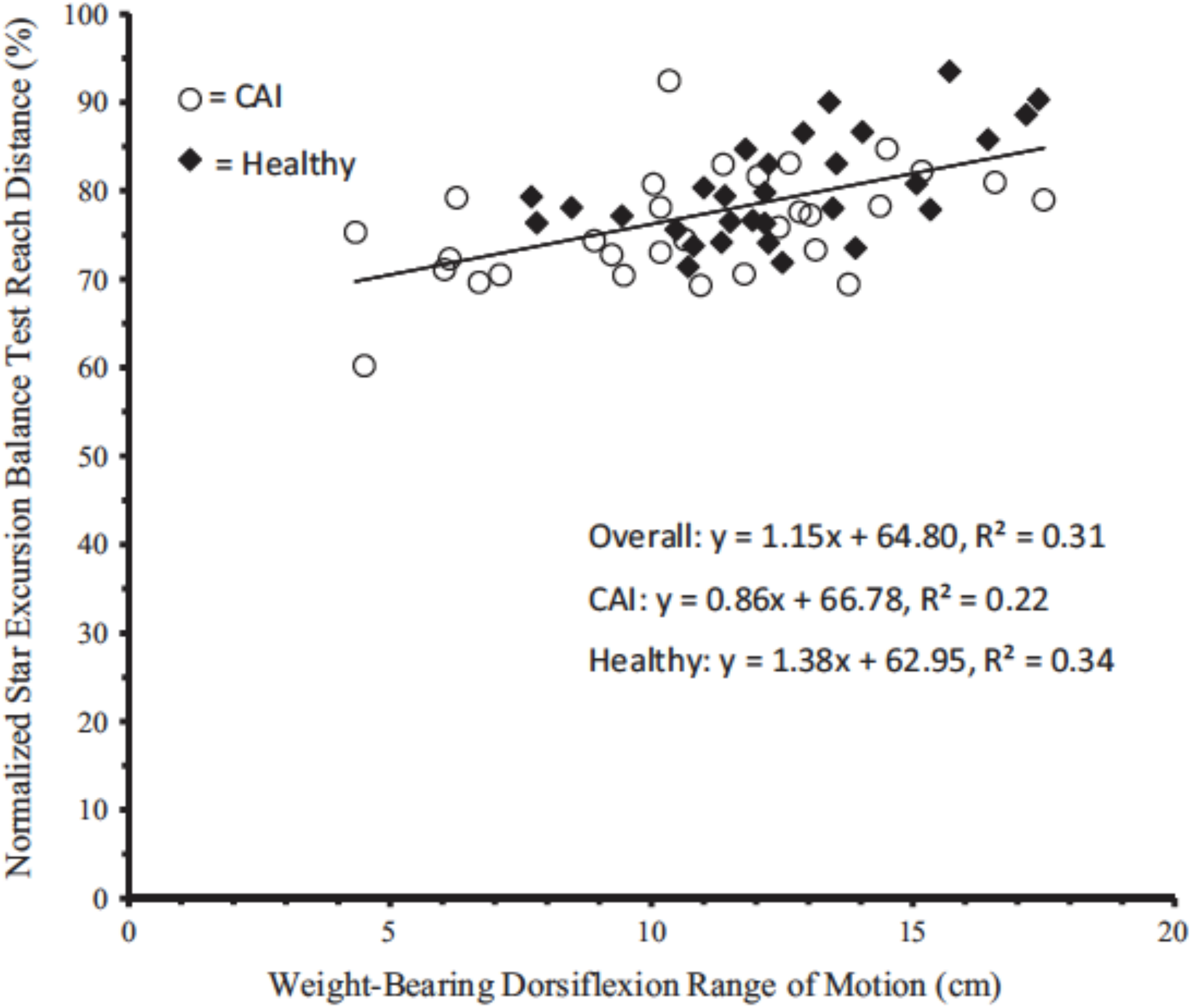
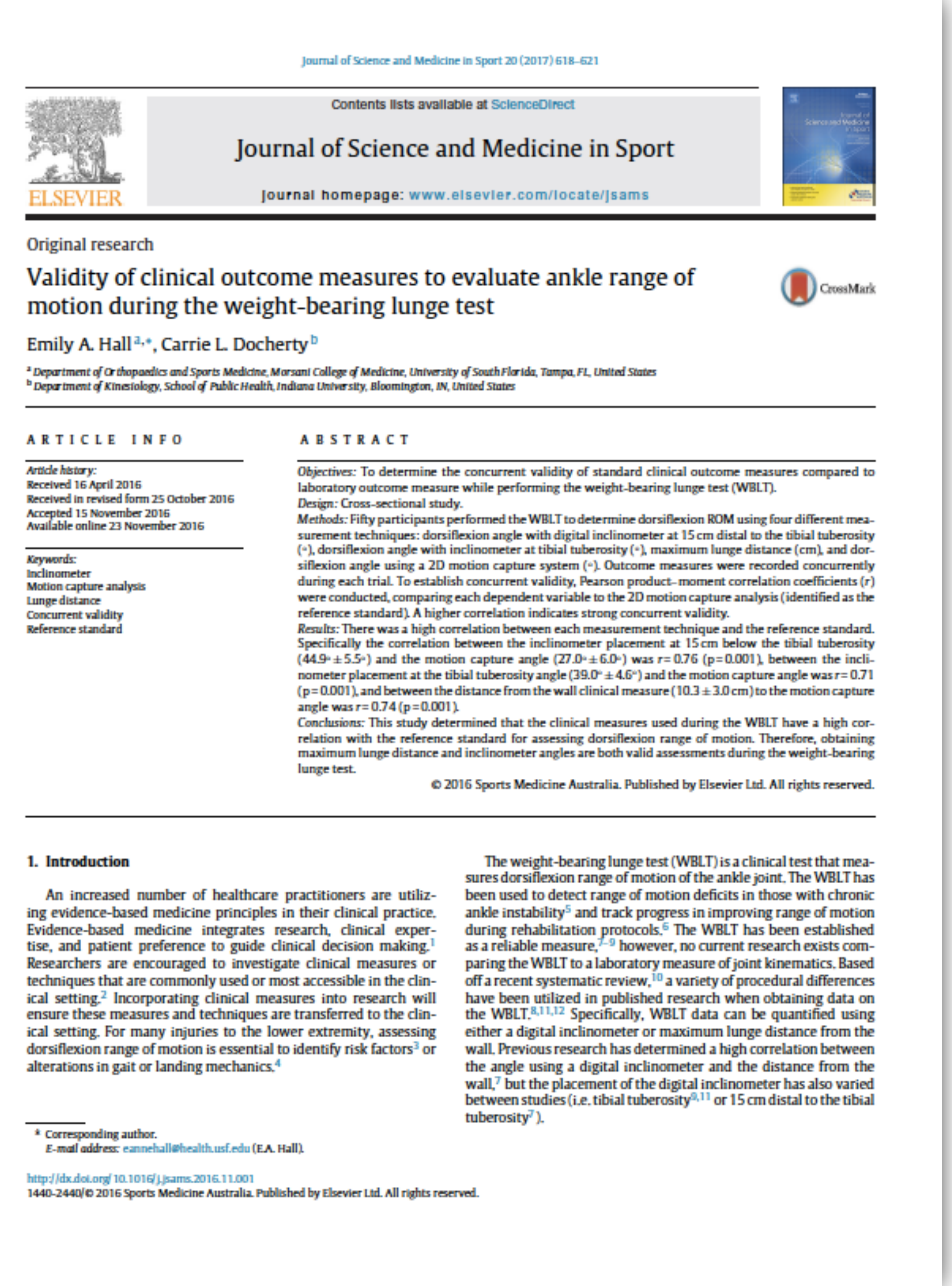


Normalized Star Excursion Balance Test Reach Distance (%)
100
90
80
70
60
50
40
30
20
10
0
○ = CAI
◆ = Healthy
Overall: y = 1.15x + 64.80, R² = 0.31
CAI: y = 0.86x + 66.78, R² = 0.22
Healthy: y = 1.38x + 62.95, R² = 0.34
0
5
10
15
20
Weight-Bearing Dorsiflexion Range of Motion (cm)



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Original research

Validity of clinical outcome measures to evaluate ankle range of motion during the weight-bearing lunge test

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ABSTRACT

Objectives: To determine the concurrent validity of standard clinical outcome measures compared to laboratory outcome measure while performing the weight-bearing lunge test (WBLT).

Design: Cross-sectional study.

Methods: Fifty participants performed the WBLT to determine dorsiflexion ROM using four different measurement techniques: dorsiflexion angle with digital inclinometer at 15 cm distal to the tibial tuberosity (°), dorsiflexion angle with inclinometer at tibial tuberosity (°), maximum lunge distance (cm), and dorsiflexion angle using a 2D motion capture system (°). Outcome measures were recorded concurrently during each trial. To establish concurrent validity, Pearson product–moment correlation coefficients (r) were conducted, comparing each dependent variable to the 2D motion capture analysis (identified as the reference standard). A higher correlation indicates strong concurrent validity.

Results: There was a high correlation between each measurement technique and the reference standard. Specifically the correlation between the inclinometer placement at 15 cm below the tibial tuberosity (44.9° ± 5.5°) and the motion capture angle (27.0° ± 6.0°) was $r = 0.76$ ($p = 0.001$), between the inclinometer placement at the tibial tuberosity angle (39.0° ± 4.6°) and the motion capture angle was $r = 0.71$ ($p = 0.001$), and between the distance from the wall clinical measure (10.3 ± 3.0 cm) to the motion capture angle was $r = 0.74$ ($p = 0.001$).

Conclusions: This study determined that the clinical measures used during the WBLT have a high correlation with the reference standard for assessing dorsiflexion range of motion. Therefore, obtaining maximum lunge distance and inclinometer angles are both valid assessments during the weight-bearing lunge test.

1. Introduction

An increased number of healthcare practitioners are utilizing evidence-based medicine principles in their clinical practice. Evidence-based medicine integrates research, clinical expertise, and patient preference to guide clinical decision making.[1] Researchers are encouraged to investigate clinical measures or techniques that are commonly used or most accessible in the clinical setting.[2] Incorporating clinical measures into research will ensure these measures and techniques are transferred to the clinical setting. For many injuries to the lower extremity, assessing dorsiflexion range of motion is essential to identify risk factors[3] or alterations in gait or landing mechanics.[4]

The weight-bearing lunge test (WBLT) is a clinical test that measures dorsiflexion range of motion of the ankle joint. The WBLT has been used to detect range of motion deficits in those with chronic ankle instability[5] and track progress in improving range of motion during rehabilitation protocols.[6] The WBLT has been established as a reliable measure,[7–9] however, no current research exists comparing the WBLT to a laboratory measure of joint kinematics. Based off a recent systematic review,[10] a variety of procedural differences have been utilized in published research when obtaining data on the WBLT.[8,11,12] Specifically, WBLT data can be quantified using either a digital inclinometer or maximum lunge distance from the wall. Previous research has determined a high correlation between the angle using a digital inclinometer and the distance from the wall,[7] but the placement of the digital inclinometer has also varied between studies (i.e. tibial tuberosity[9,11] or 15 cm distal to the tibial tuberosity[7]).

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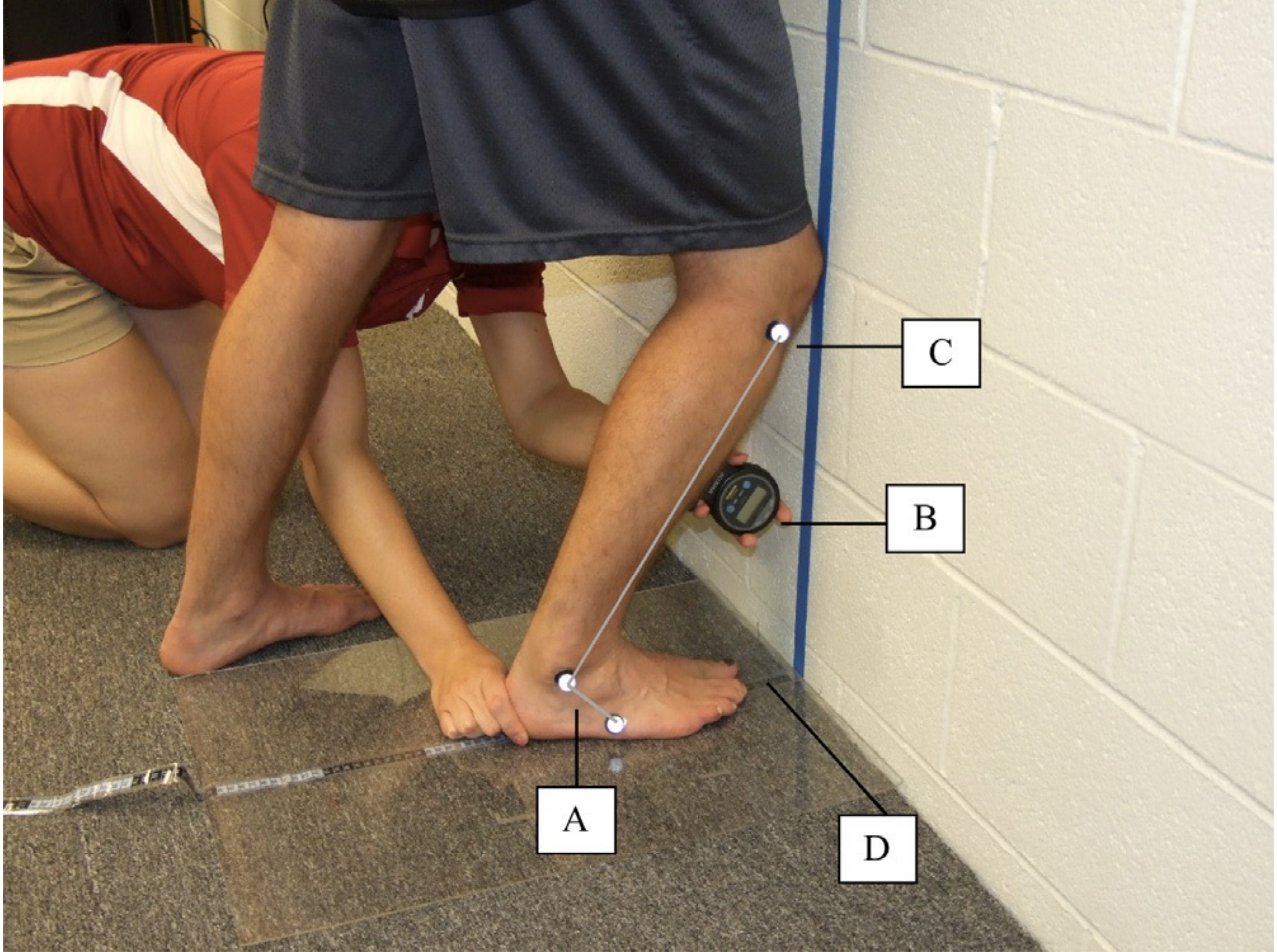
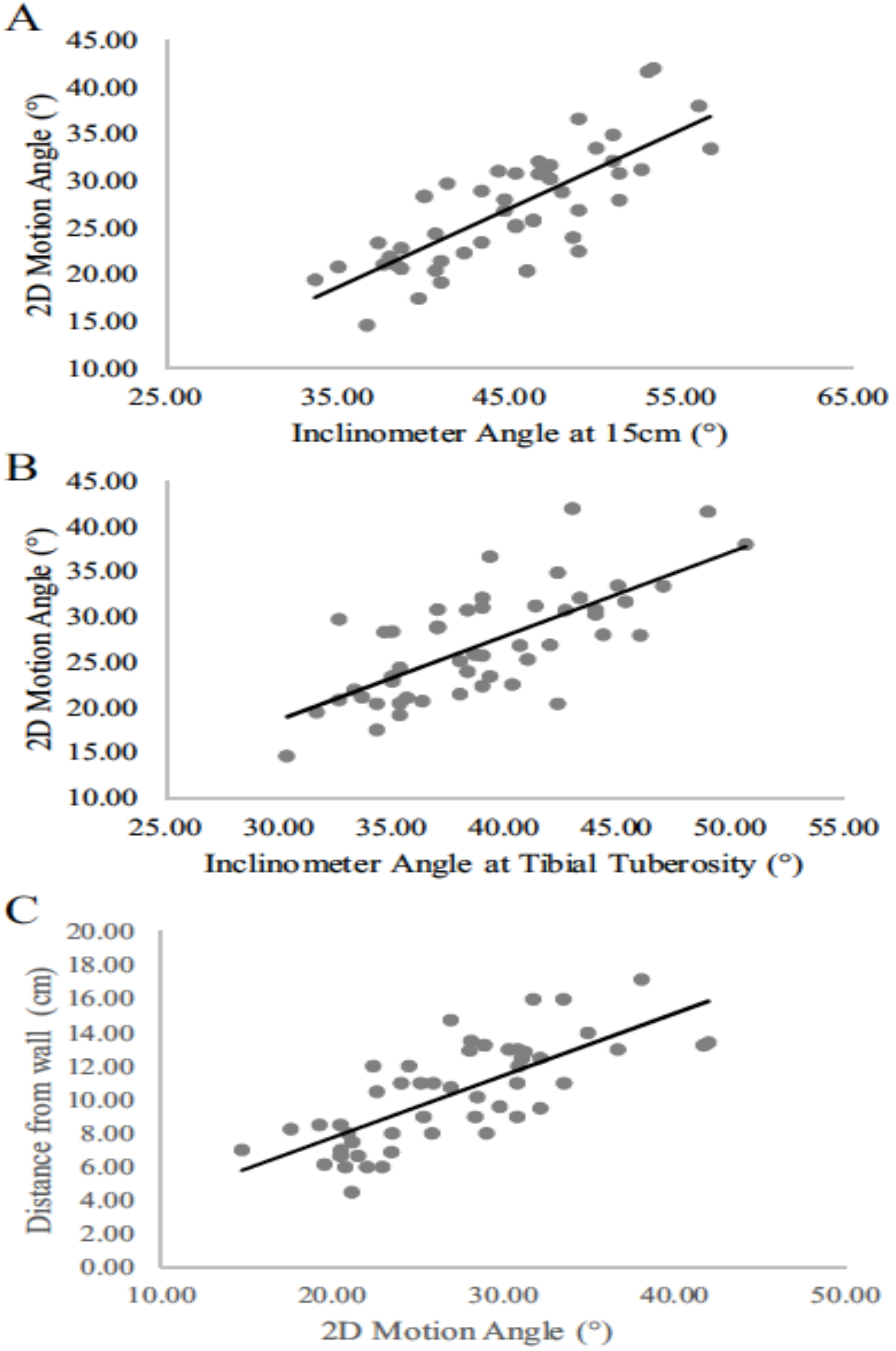
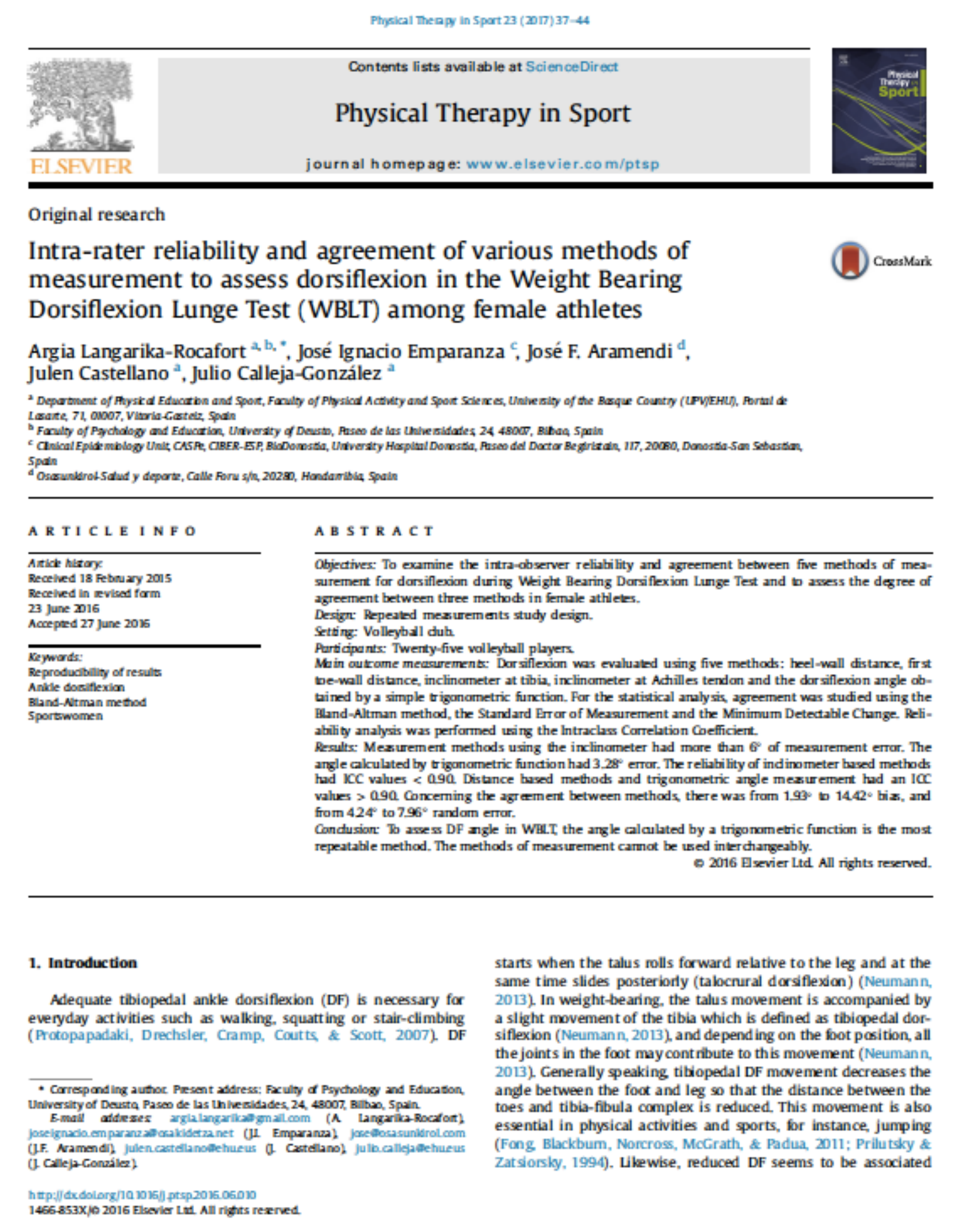

C
B
A
D


A
2D Motion Angle (°)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
25.00
35.00
45.00
55.00
65.00
Inclinometer Angle at 15cm (°)
B
2D Motion Angle (°)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
Inclinometer Angle at Tibial Tuberosity (°)
C
Distance from wall (cm)
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
10.00
20.00
30.00
40.00
50.00
2D Motion Angle (°)



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Original research

Intra-rater reliability and agreement of various methods of measurement to assess dorsiflexion in the Weight Bearing Dorsiflexion Lunge Test (WBLT) among female athletes

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ABSTRACT

Objectives: To examine the intra-observer reliability and agreement between five methods of measurement for dorsiflexion during Weight Bearing Dorsiflexion Lunge Test and to assess the degree of agreement between three methods in female athletes.
Design: Repeated measurements study design.
Setting: Volleyball club.
Participants: Twenty-five volleyball players.
Main outcome measurements: Dorsiflexion was evaluated using five methods: heel-wall distance, first toe-wall distance, inclinometer at tibia, inclinometer at Achilles tendon and the dorsiflexion angle obtained by a simple trigonometric function. For the statistical analysis, agreement was studied using the Bland-Altman method, the Standard Error of Measurement and the Minimum Detectable Change. Reliability analysis was performed using the Intraclass Correlation Coefficient.
Results: Measurement methods using the inclinometer had more than 6° of measurement error. The angle calculated by trigonometric function had 3.28° error. The reliability of inclinometer based methods had ICC values < 0.90. Distance based methods and trigonometric angle measurement had an ICC values > 0.90. Concerning the agreement between methods, there was from 1.93° to 14.42° bias, and from 4.24° to 7.96° random error.
Conclusion: To assess DF angle in WBLT, the angle calculated by a trigonometric function is the most repeatable method. The methods of measurement cannot be used interchangeably.

1. Introduction

Adequate tibiopedal ankle dorsiflexion (DF) is necessary for everyday activities such as walking, squatting or stair-climbing (Protopapadaki, Drechsler, Cramp, Coutts, & Scott, 2007). DF starts when the talus rolls forward relative to the leg and at the same time slides posteriorly (talocrural dorsiflexion) (Neumann, 2013). In weight-bearing, the talus movement is accompanied by a slight movement of the tibia which is defined as tibiopedal dorsiflexion (Neumann, 2013), and depending on the foot position, all the joints in the foot may contribute to this movement (Neumann, 2013). Generally speaking, tibiopedal DF movement decreases the angle between the foot and leg so that the distance between the toes and tibia-fibula complex is reduced. This movement is also essential in physical activities and sports, for instance, jumping (Fong, Blackburn, Norcross, McGrath, & Padua, 2011; Prilutsky & Zatsiorsky, 1994). Likewise, reduced DF seems to be associated

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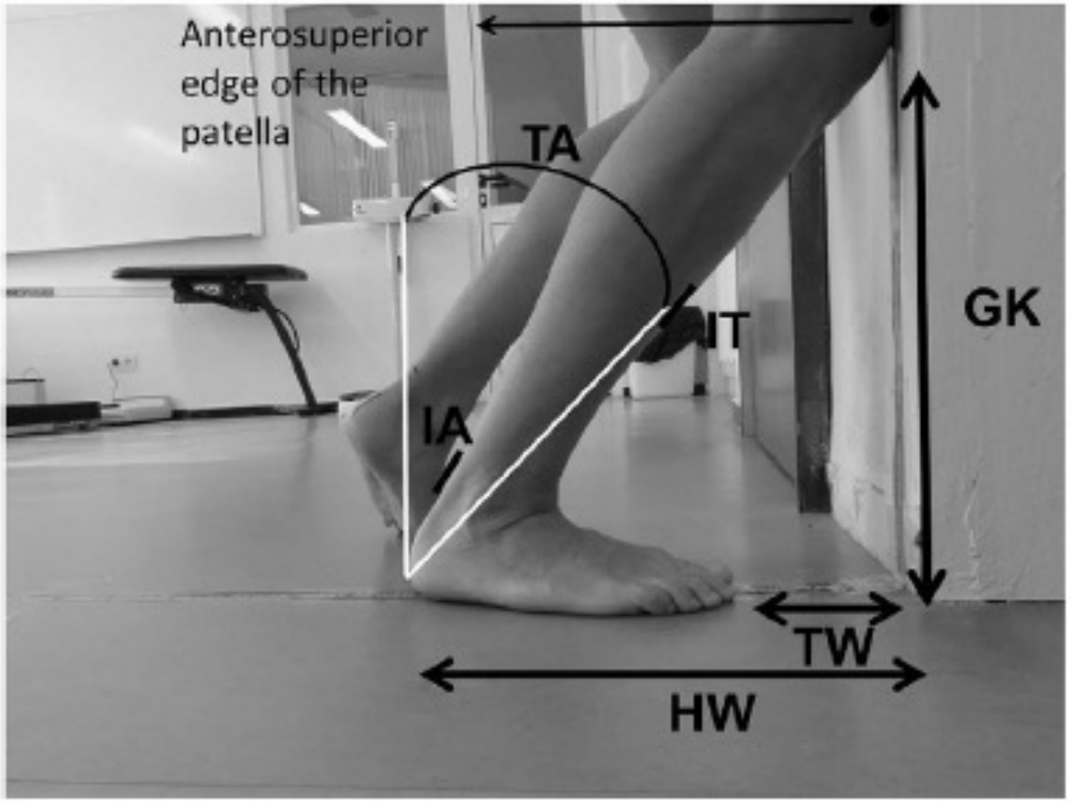

Fig. 1. A Participant in the Weight Bearing Dorsiflexión Lunge Test and the measurement methods analyzed in this study. Abbreviations: HW, Heel-wall distance; GK, Ground-knee distance; IA, Inclinometer in the Achilles; IT, Inclinometer in the tibia; TA, Trigonometric dorsiflexion angle; TW, Toe-wall distance.

Results of Intraclass Correlation Coefficient (ICC), Standard Error of measurement (SEM), and Minimum Detectable Change (MDC) of the study of measurement method reliability.

Variable	n	Mean	SD	ICC	ICC 95% CI	SEM	MDC
HW (cm)	50	37.98	3.44	0.96	0.94–0.98	0.66	1.82
TW (cm)	50	13.36	3.05	0.95	0.91–0.97	0.68	1.89
GK (cm)	50	34.72	4.08	0.95	0.91–0.97	0.93	2.57
IA (°)	50	35.12	6.24	0.87	0.78–0.92	2.28	6.33
IT (°)	50	49.55	6.11	0.87	0.79–0.93	2.17	6.02
TA (°)	50	47.62	5.20	0.95	0.91–0.97	1.18	3.26

Abbreviations: GK, Ground-knee distance; HW, Heel-wall distance; IA, Inclinometer in Achilles tendon; ICC, Intraclass Correlation Coefficient; INF, inferior; IT, Inclinometer in tibia; LOA, limit of agreement; MDC; Minimum Detectable Change; NS, Non-significant; PCC, Pearson Correlation Coefficient; SD, Standard deviation; SEM; Standard Error of measurement; SUP, superior; p, statistical significance; TA, Trigonometric dorsiflexion angle; TW, Toe-wall distance; 95% CI, 95% confidence interval.

BRIEF REPORT

Reliability and Validity of a Smartphone App to Measure Joint Range

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Disclosures:

Sophie Louise Vohralik, BAppSc(Physiotherapy)(Hons), and Annika Rose Bowen, BAppSc(Physiotherapy)(Hons), are joint first authors.

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American Journal of Physical Medicine & Rehabilitation

DOI: 10.1097/PHM.0000000000000221

ABSTRACT

Vohralik SL, Bowen AR, Burns J, Hiller CE, Nightingale EJ: Reliability and validity of a smartphone app to measure joint range. Am J Phys Med Rehabil 2015;94:325–330.

In clinical and research settings, objective range of motion measurement is an essential component of lower limb assessment and treatment evaluation. One reliable tool is the digital inclinometer; however, availability and cost preclude its widespread use. Smartphone apps are now widely available, allowing smartphones to be used as an inclinometer. Reliability and validity studies of new technologies are scarce. Intrarater and interrater reliability of the iHandy Level app installed on a smartphone and an inclinometer were assessed in 20 participants for ankle dorsiflexion using a weight-bearing lunge test. Criterion validity was assessed between a Fastrak and the app, and construct validity was assessed between the inclinometer and the app. Intraclass correlation coefficients$_{2,1}$ demonstrated excellent intrarater and interrater reliability (intraclass correlation coefficient, 0.97 and 0.76, respectively). Tests of validity demonstrated excellent correlation between all three methods ($r^2 > 0.99$). The smartphone app is both reliable and valid, provides a low-cost method of measuring range of motion, and can be easily incorporated into clinical practice.

Key Words: Range of Motion, Ankle Joint, Measurement Accuracy, Biomedical Technology, Cellular Phone

BACKGROUND

Accurate measurement of joint range of motion is often required in biomechanical research and clinical practice. One of the most reliable tools to measure joint range is the digital inclinometer[1,2]; however, accessibility and cost often preclude its use. Several methods have been reported in the literature for measuring joint range, such as video-based three-dimensional kinematics,[3] Fastrak,[4,5] goniometers,[2,3,6–8] and digital inclinometers.[2,3,7,9]

Considering just ankle dorsiflexion range, only the reliability of digital inclinometer measurements has been considered to date.[1–3,7,9] The validity of digital inclinometer measurements is really considered only in cervical spine and shoulder measurement, in which the large range of motion across multiple planes can alter the values obtained considerably.[10,11] With the advent of the smartphone, there are now many free applications (apps) available (e.g., the TiltMeter, Clinometer, and

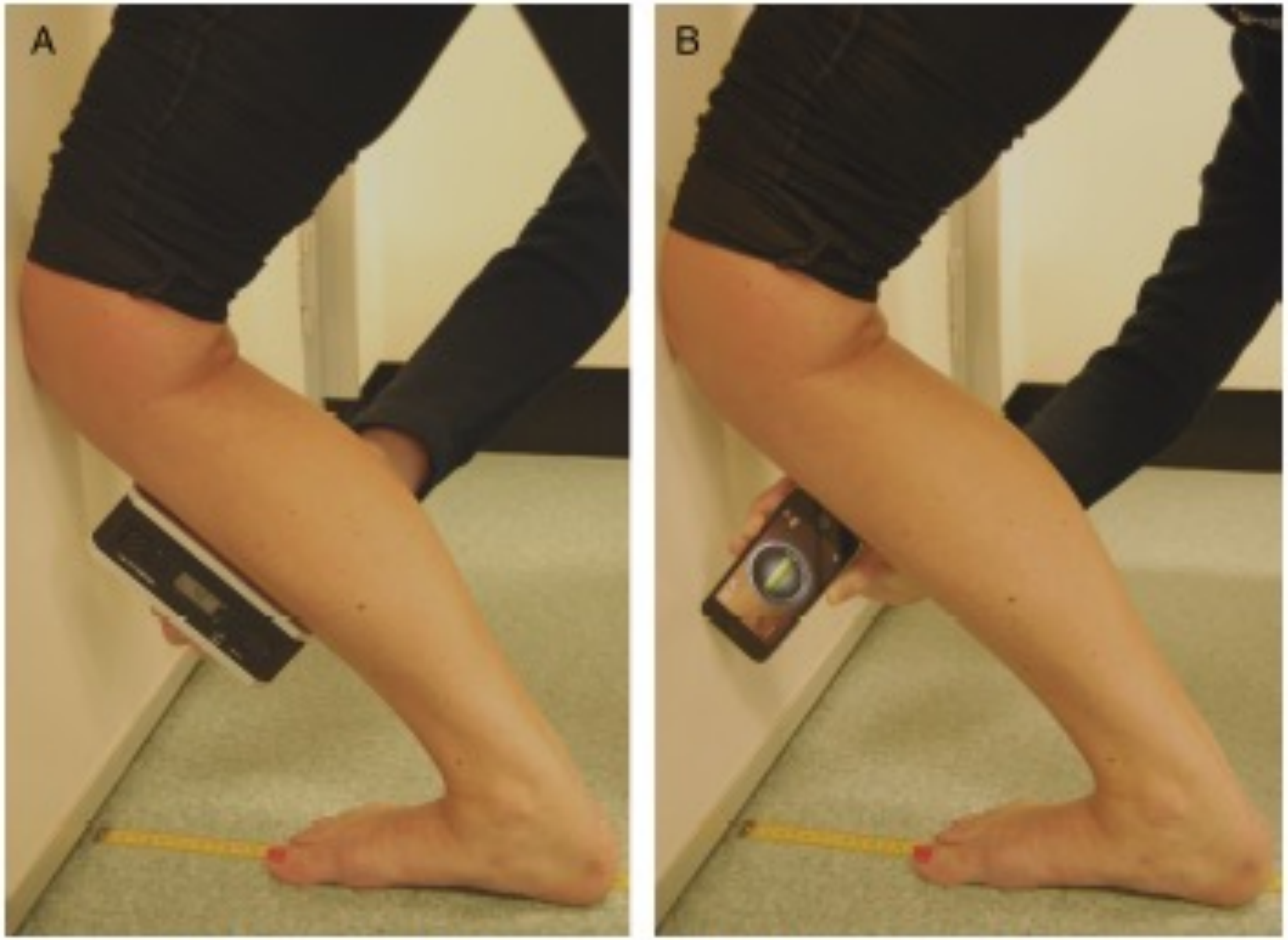
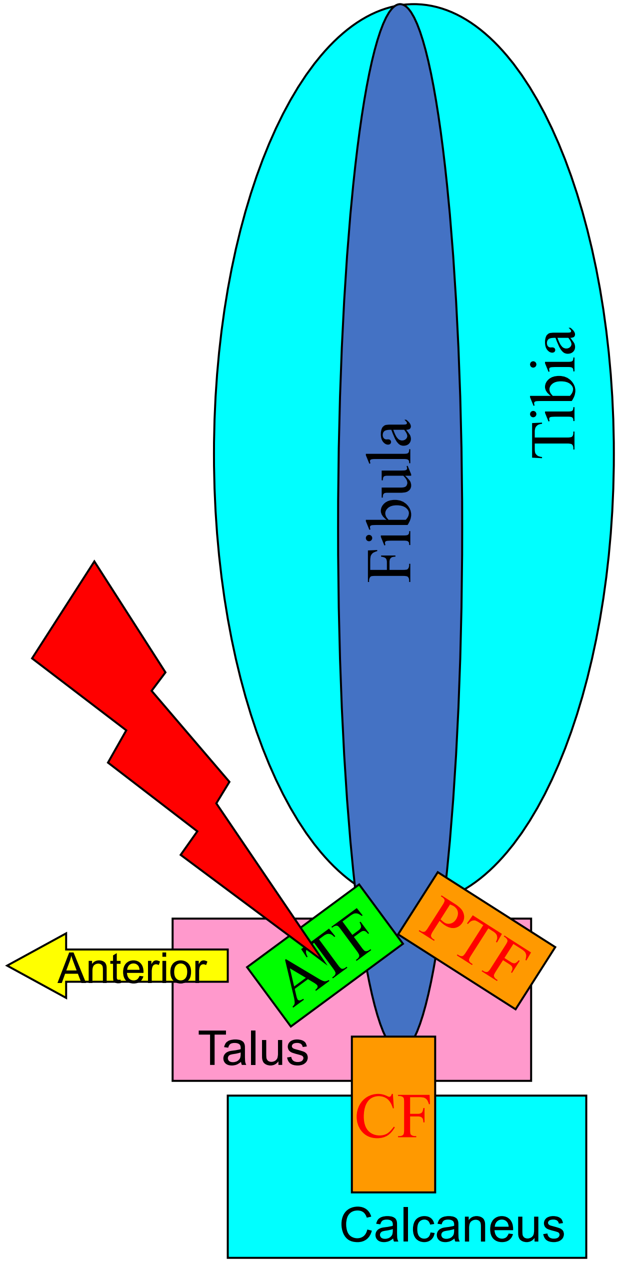


FIGURE 1 *Measurement devices used: baseline inclinometer (A) and iPhone with iHandy Level app (B).*


Tibia
Fibula
ATF
PTF
Anterior
Talus
CF
Calcaneus

ORIGINAL ARTICLE

Talar Positional Fault in Persons With Chronic Ankle Instability

Erik A. Wikstrom, PhD, Tricia J. Hubbard, PhD

ABSTRACT. Wikstrom EA, Hubbard TJ. Talar positional fault in persons with chronic ankle instability. Arch Phys Med Rehabil 2010;91:1267-71.

Objective: To determine whether sagittal plane talar position differs between uninjured controls and individuals with chronic ankle instability (CAI) using lateral ankle radiographs.

Design: Single-blind case control.

Setting: University-based sports medicine research laboratory.

Participants: University students (N=48) volunteered to participate. Twenty-four uninjured controls (12 men, 12 women; mean ± SD, 21.8±2.6y; 170±10cm; 73±16kg), and 24 adults with CAI (12 men, 12 women; 21.7±2.8y; 175±13cm; 71±13kg) participated.

Intervention: A single nonweight-bearing lateral radiograph was taken of each ankle. Subjects were positioned side lying with the hip and knee in a neutral position in the transverse plane and the ankle joint in a neutral position (90° of dorsiflexion, 0° of inversion/eversion).

Main Outcome Measure: The sagittal plane talar position was calculated as the distance between the most anterior margin of the inferior tibia and the most anterior margin of the talar dome in millimeters for each radiograph.

Results: Talar position was significantly more anterior in the involved CAI limb (3.69±1.37mm) than the uninvolved CAI limb (2.98±1.61mm; *P*=.03). Additionally, an anterior talar position was significantly greater in the involved CAI limb than the matched control limb (2.65±1.24cm; *P*<.01). No differences were found between the uninvolved CAI limb and the matched control group limb (*P*=.57) or between the limbs of the uninjured control group (*P*=.75). Intratester reliability was found to be .90, while intertester reliability was .78.

Conclusions: An anterior talar positional fault is present in the involved limb of individuals with CAI relative to their uninvolved limb and compared with the matched limb of a control group. The talar position measurement technique has excellent intratester and intertester reliability.

Key Words: Ankle joint; Joint instability; Radiography; Rehabilitation.

LATERAL ANKLE SPRAINS are an extremely common musculoskeletal injury[1-3] and occur at an incredible incidence of 25,000 a day in the United States.[4] Unfortunately, a lateral ankle sprain is often erroneously thought to be an innocuous injury, when in truth, lateral ankle sprains represent a significant public health problem because of the joint's susceptibility to recurrent injury. Indeed, the recurrence rate of lateral ankle sprains is greater than 70%,[5] and up to 75% of people who sprain their ankle develop CAI.[6] Further, CAI is a leading cause of posttraumatic osteoarthritis in the ankle.[7,8]

Currently, CAI is believed to be the result of a cascade of maladaptive changes that start immediately after an initial sprain. More specifically, mechanical and/or structural changes (eg, increased ligament laxity, altered joint alignment, impaired arthrokinematics)[9-12] are thought to lead to changes in sensorimotor control.[11,13] Further, mechanical and/or structural alterations at the ankle joint will lead to changes in joint loads during weight-bearing activities, and they are most likely the reason individuals with a history of lateral ankle sprains often develop posttraumatic ankle osteoarthritis.

One treatment currently and commonly used to treat lateral ankle sprains and CAI is joint mobilization. This manual therapy technique is purported to restore proper arthrokinematics and alterations in structural alignment such as a positional fault as first proposed by Mulligan.[14] At the ankle, an anterior positional fault of the talus is believed to be the result of an anterior subluxation of the talus on the tibia immediately after an inversion ankle sprain.[12] While this belief is speculative, an anterior positional fault of the talus has been hypothesized to alter the arthrokinematic (posterior talar glide)[12] and osteokinematic restrictions (dorsiflexion range of motion) reported after lateral ankle trauma.[12,15,16] Further, the presence of a talar positional fault is a possible explanation for the reported effectiveness of anterior-to-posterior mobilizations of the talus on the tibia at improving arthrokinematic[17] and osteokinematic restrictions[17-20] in patients with a history of lateral ankle sprains, including CAI.

While previous investigations[12,17-20] have postulated that a talar positional fault may exist and/or may explain restricted posterior glides of the talus, no investigation has directly measured sagittal plane talar position via measurements from radiographic images in subjects with CAI. Thus, the purpose of this investigation was to determine whether sagittal plane talar position differs among uninjured controls and individuals with CAI. We hypothesized that individuals with CAI will have an anterior talar position in the sagittal plane compared with controls and that individuals with CAI will have an anterior talar position in the sagittal plane in their involved limb relative to their uninvolved limb. The secondary objective of this

List of Abbreviations

AJFAT	Ankle Joint Functional Assessment Test
CAI	chronic ankle instability
ICC	intraclass correlation coefficient
kVp	kilovolt peak
MaS	milliampere seconds

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Fig 1. Talar position measurement. The distance in the sagittal plane between the most anterior margin of the inferior tibia and the most anterior margin of the talar dome only in the sagittal plane (ie, between the white vertical lines) was measured in millimeters.

Table 2: Sagittal Plane Talar Position Group Means (mm), SDs, and 95% Confidence Intervals

Group	Ankle	Mean ± SD	95% Confidence Interval
CAI	Involved*†	3.7±1.4	3.1–4.3
	Uninvolved	3.0±1.6	2.3–3.7
Control	Matched involved	2.7±1.2	2.1–3.2
	Matched uninvolved	2.8±1.3	2.3–3.3

*A significant difference from the uninvolved limb of the CAI group ($P<.05$).

†A significant difference from the involved limb of the control group ($P<.05$).

Two-Week Joint Mobilization Intervention Improves Self-Reported Function, Range of Motion, and Dynamic Balance in Those With Chronic Ankle Instability

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ABSTRACT: We examined the effect of a 2-week anterior-to-posterior ankle joint mobilization intervention on weight-bearing dorsiflexion range of motion (ROM), dynamic balance, and self-reported function in subjects with chronic ankle instability (CAI). In this prospective cohort study, subjects received six Maitland Grade III anterior-to-posterior joint mobilization treatments over 2 weeks. Weight-bearing dorsiflexion ROM, the anterior, posteromedial, and posterolateral reach directions of the Star Excursion Balance Test (SEBT), and self-reported function on the Foot and Ankle Ability Measure (FAAM) were assessed 1 week before the intervention (baseline), prior to the first treatment (pre-intervention), 24–48 h following the final treatment (post-intervention), and 1 week later (1-week follow-up) in 12 adults (6 males and 6 females) with CAI. The results indicate that dorsiflexion ROM, reach distance in all directions of the SEBT, and the FAAM improved ($p < 0.05$ for all) in all measures following the intervention compared to those prior to the intervention. No differences were observed in any assessments between the baseline and pre-intervention measures or between the post-intervention and 1-week follow-up measures ($p > 0.05$). These results indicate that the joint mobilization intervention that targeted posterior talar glide was able to improve measures of function in adults with CAI for at least 1 week. © 2012 Orthopaedic Research Society. Published by Wiley Periodicals, Inc. J Orthop Res 30:1798–1804, 2012

Keywords: ankle sprain; dorsiflexion; balance; manual therapy; self-reported function

Lateral ankle sprains continue to be the most common injury sustained by physically active individuals and create an annual healthcare burden of over $4 billion in the U.S. alone.[1,2] Although these injuries are often considered innocuous, up to 70% of individuals who sustain a single lateral ankle sprain experience residual symptoms, recurrent bouts of instability, additional ankle sprains, and reduced functional capacity.[3–5] These negative sequelae associated with acute ankle sprains are the primary characteristics of chronic ankle instability (CAI).[6] The prevalence of CAI combined with the associated decreased quality of life[3] and risk of developing co-morbidities such as post-traumatic ankle osteoarthritis[7,8] advocates for further development of interventions to address this clinical phenomenon.

CAI has been linked to several mechanical and functional insufficiencies; however, their relationship as it relates to the manifestation of this condition is unclear.[6,9] Several mechanical impairments have been identified as contributing factors for CAI.[6] The primary mechanical impairments include increased anterior joint laxity,[10] reduced posterior talar glide,[11] and reduced dorsiflexion range of motion (ROM).[12,13] Dorsiflexion ROM deficits may be related to a disruption in normal talar arthrokinematics as a result of restrictions in noncontractile tissues and degenerative changes in ankle complex structure.[6] This is supported by studies that identified either restrictions in posterior talar glide[11,14] or the presence of an anterior positional fault of the talus in relation to the ankle mortise.[15,16] A loss of dorsiflexion ROM that is arthrogenic in nature may also contribute to the functional impairments associated with CAI by disrupting the normal transmission of afferent information available to the sensorimotor system.[6,17] Deficits in postural control and other functional impairments are thought to be the result of a loss in somatosensory information from damaged ligamentous mechanoreceptors; however, alterations in sensory input may also be associated with changes in arthrokinematic function.[16–18] While other factors such as central adaptations in motor organization may contribute to sensorimotor alterations,[19] the potential synergistic relationship between local mechanical and functional alterations associated with CAI warrants further investigation.

While the connection between specific impairments and the clinical manifestation of CAI is unclear, interventions that address multiple aspects of impairment are essential for alleviating activity limitations and participation restrictions in people with CAI.[9] To address mechanical impairments, previous investigators[14,17,17,20,21] utilized joint mobilization manual therapy techniques to address deficits in posterior talar glide and dorsiflexion ROM. Joint mobilization was used to increase ROM and arthrokinematic

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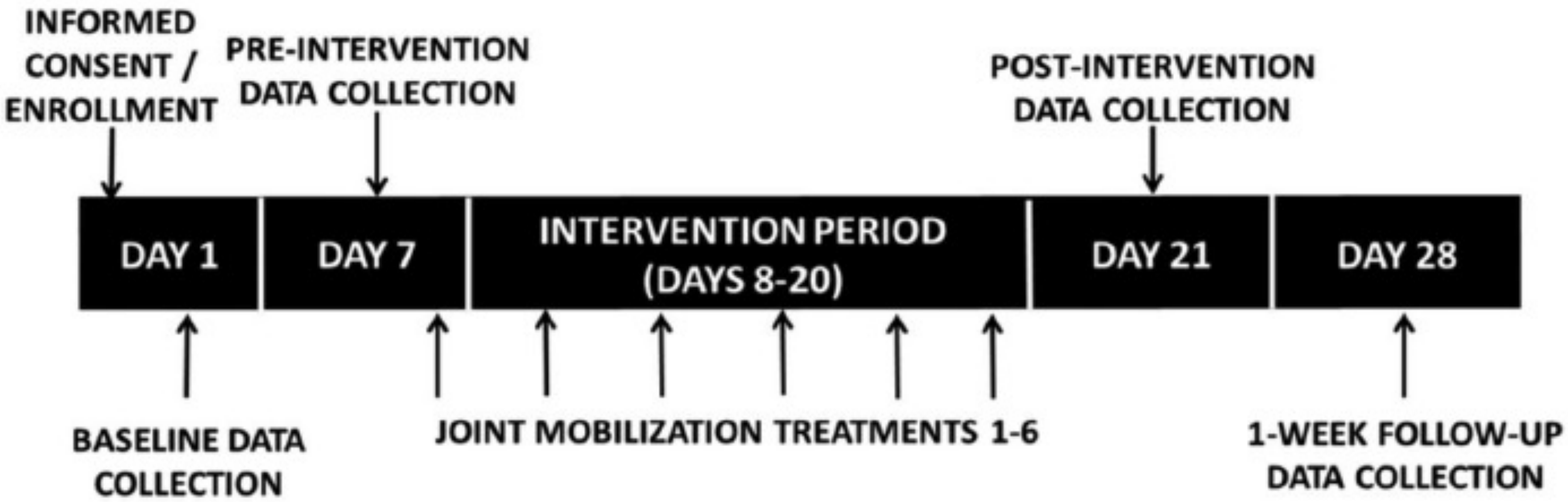


Figure 1. Study timeline representing the four data collection sessions (baseline, pre-intervention, post-intervention, 1-week follow-up) and the six joint mobilization treatment sessions over a 28-day period.

The intervention consisted of six visits to the laboratory.

During each session, each subject received 2, 2-min sets of Maitland Grade II talocrural joint traction and 4, 2-min sets of Maitland Grade III talocrural joint mobilization with 1 min of rest between sets. Therefore, the treatment volume was 12 min (4 min of traction and 8 min of joint mobilization) during each session.

Table 1. Mean ± SD and Minimal Detectable Change (MDC) for the Foot and Ankle Ability Measure Activities of Daily Living (FAAM-ADL), the FAAM-Sport, Dorsiflexion ROM, and the Anterior, Posteromedial, and Posterolateral Directions of the Star Excursion Balance Test (SEBT) across the Four Testing Sessions ($n = 12$).

Dependent Variable	Baseline	Pre-Intervention	Post-Intervention	1-Week Follow-up	MDC
FAAM-ADL (%)	77.99 ± 13.11	78.27 ± 12.62	87.30 ± 11.07[a,b]	86.80 ± 11.06[a,b]	3.96
FAAM-Sport (%)	56.25 ± 14.72	58.59 ± 11.08	73.69 ± 17.65[a,b]	74.21 ± 18.94[a,b]	7.90
Dorsiflexion ROM (cm)	10.87 ± 3.71	10.83 ± 3.86	12.18 ± 3.65[a,b]	12.29 ± 3.58[a,b]	0.26
Anterior SEBT (%)	75.06 ± 5.19	76.18 ± 5.76	78.30 ± 5.63[a,b]	78.71 ± 4.97[a,b]	1.56
Posteromedial SEBT (%)	93.30 ± 10.37	91.86 ± 10.33	96.23 ± 10.95[a,b]	97.47 ± 11.20[a,b]	3.36
Posterolateral SEBT (%)	85.92 ± 11.97	87.15 ± 12.60	91.92 ± 11.15[a,b]	93.09 ± 12.96[a,b]	4.28

[a] Significant increase compared to baseline ($p \leq 0.05$). [b] Significant increase compared to pre-intervention ($p \leq 0.05$).

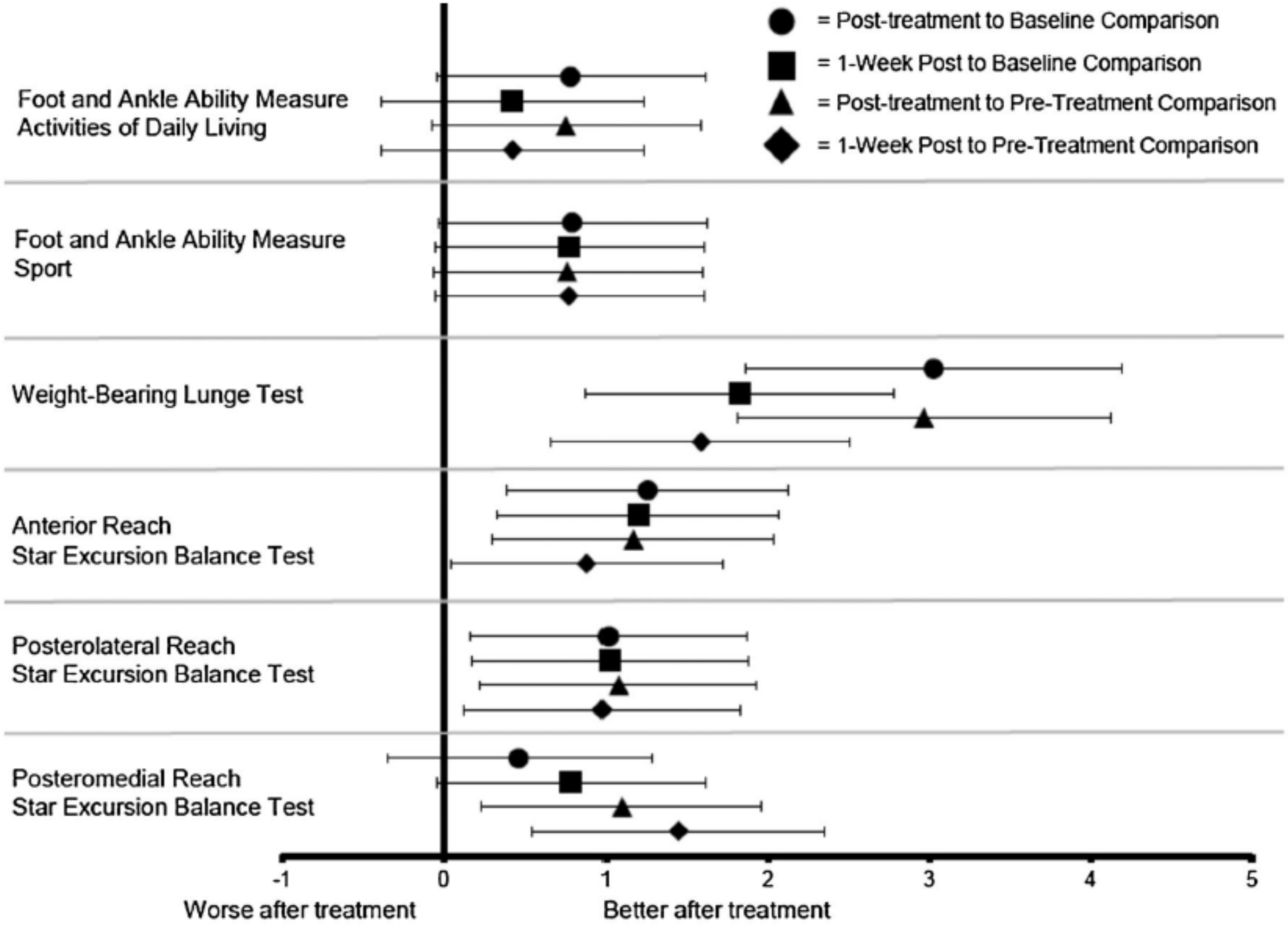
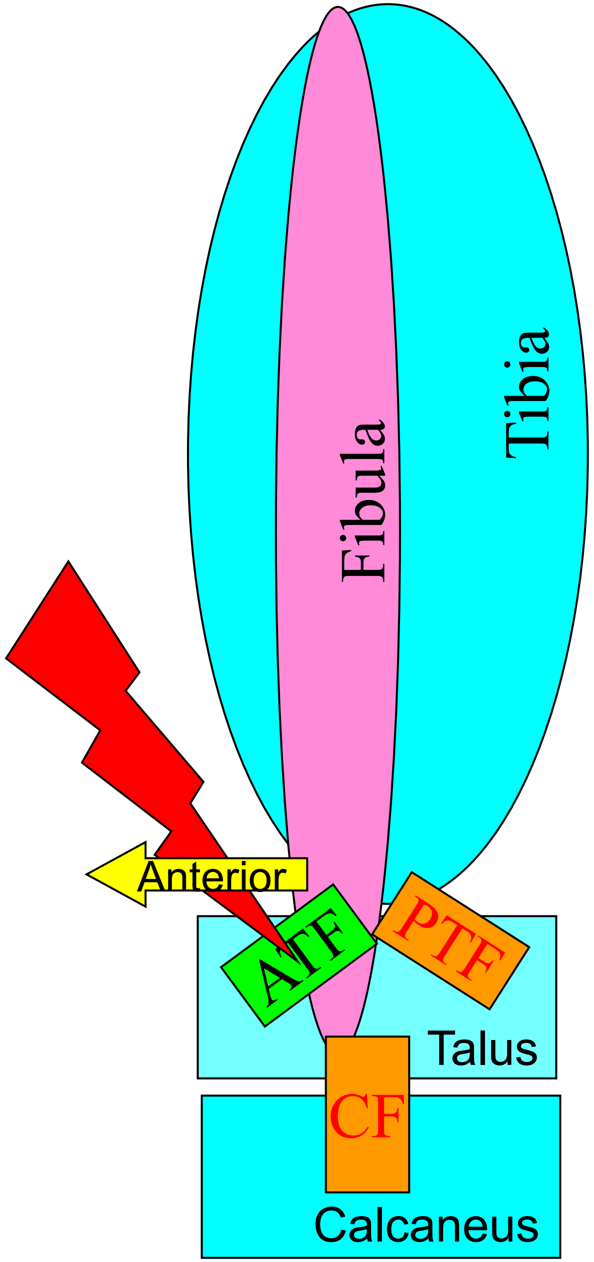


Figure 2. Effect sizes and 95% confidence intervals for the Foot and Ankle Ability Measure Activities of Daily Living, the Foot and Ankle Ability Measure Sport, Weight-Bearing Lunge Test, and the anterior, posteromedial, and posterolateral directions of the Star Excursion Balance Test for all significant post hoc comparisons. Positive effect sizes represent improvements following the joint mobilization intervention.


Tibia
Fibula
Anterior
ATF
PTF
Talus
CF
Calcaneus

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Fibular Position in Individuals With Self-Reported Chronic Ankle Instability

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Jay Hertel, PhD, ATC[2]
Paul Sherbondy, MD[3]

Study Design: Case control study.
Objectives: The purpose of this study was to assess the position of the distal fibula in individuals with chronic ankle instability (CAI).
Background: Recent literature has suggested that a positional fault of the fibula on the tibia may contribute to CAI; however, there is a lack of objective scientific evidence to support this claim.
Methods and Measures: Thirty subjects with unilateral CAI (mean ± SD age, 20.3 ± 1.3 years) and 30 subjects with no previous history of ankle injury (mean ± SD age, 21.3 ± 3.8 years) participated in this study. Subjects completed a pair of subjective functional scales and fluoroscopic lateral images of both the right and left ankles were recorded. The distance from the anterior margin of the distal tibia to the anterior margin of the distal fibula was measured in millimeters. Nonparametric statistics were used to assess the relationship between fibular position and CAI status.
Results: There were significant differences between the CAI and control group ankles ($P = .045$) and within the involved and uninvolved sides of the CAI group ($P = .006$). Those with CAI had a significantly more anterior fibular position on their involved ankle in relation to their uninvolved limb, and the ankles of the control group.
Conclusions: The fibula was positioned significantly more anterior in relation to the tibia in subjects with unilateral CAI. It is unclear if repetitive bouts of ankle instability caused the anterior fibular position or if the more anterior position was a predisposing factor to injury. *J Orthop Sports Phys Ther 2006;36:3-9.*

Key Words: *ankle sprain, fibula, fluoroscopy, tibiofibular joint*

More than 23 000 ankle sprains have been estimated to occur per day in the United States, which equates to 1 sprain per 10 000 people daily.[18] However, it has been reported that 55% of individuals who sprain their ankle do not seek treatment from a health care professional, so the incidence of injury may be much greater.[20] Of particular concern is the high proportion (up to 70%) of patients who will suffer from repetitive ankle sprains and chronic symptoms after initial injury.[20] Chronic ankle instability (CAI) cannot only limit activity but may lead to an increased risk of osteoarthritis and articular degeneration at the ankle.[12]

Mechanical ankle instability (MAI) is one hypothesized cause of CAI.[8,13,25,26] One detrimental effect of MAI is that it can lead to abnormal ankle mechanics.[5] Such abnormal mechanics can be in the form of hypermobility (increased joint laxity)[5] or hypomobility (decreased laxity).[5] Some studies[2,14,18] have reported an increased laxity at the talocrural and subtalar joints in individuals with CAI; however, other studies[7,23,25] reported no increase in ligamentous laxity. The variability in assessment techniques is one contributing factor to the differences in results. One shortcoming of MAI research is the little consideration given to the role of positional faults at the ankle complex in the etiology of CAI.

The relative void in the literature regarding positional faults gives the impression that they do not contribute to residual symptoms or increased risk for reinjury. For joints to move through their full range of motion (physiologic motion) normal arthrokinematic motions must occur.[5] Arthrokinematics describes movement of articular surfaces of a joint as the bones move through a range of motion. Some of the arthrokinematic motions that occur are accessory motions. Accessory motions are movements that the individual cannot voluntarily produce.[5] Examples include rolling and gliding of joints. Positional faults may

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The protocol for this study was approved by the Pennsylvania State University Institutional Review Board.
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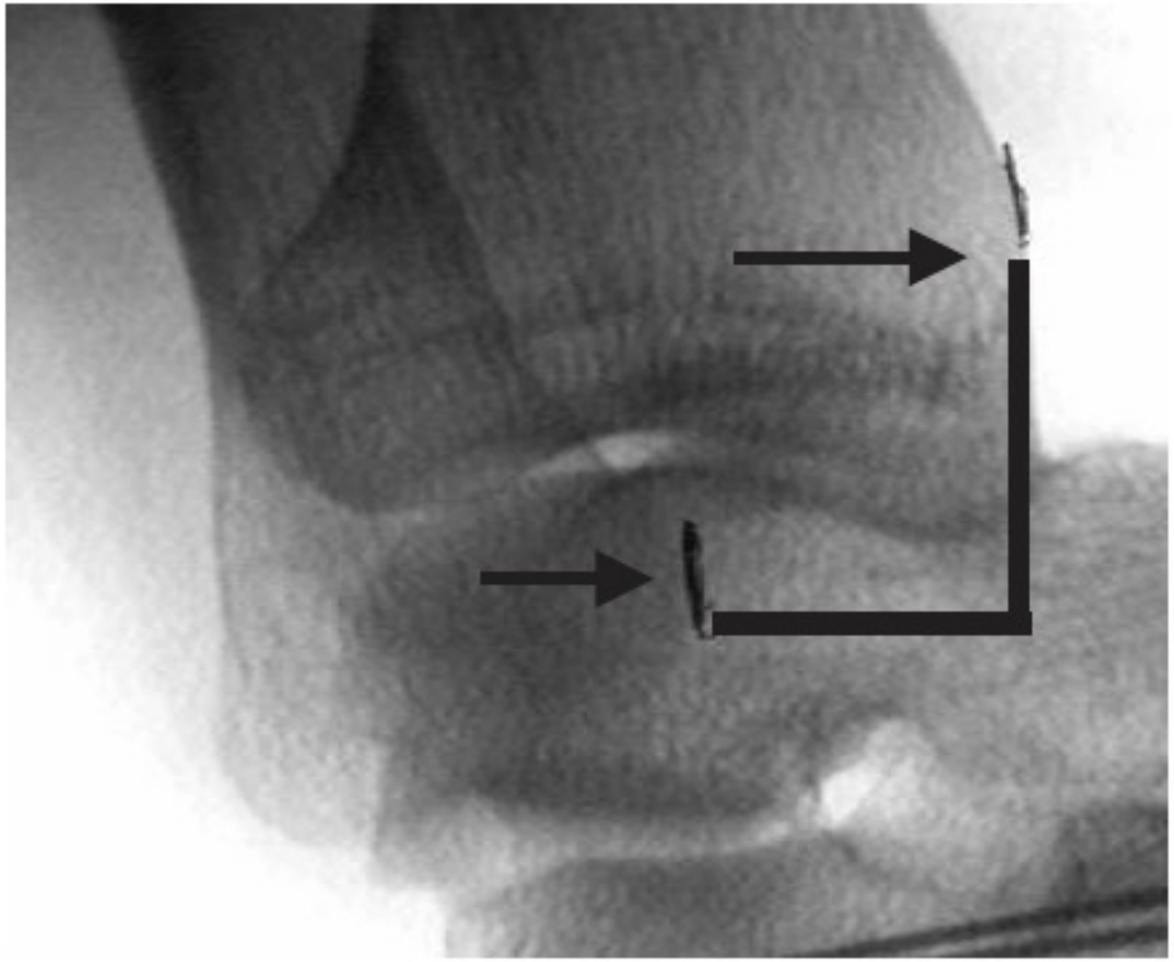

FIGURE 2. Fibular position measurement. The distance between the anterior edge of the distal fibula and the anterior edge of the distal tibia was measured in centimeters and then converted to millimeters.

TABLE 1. Means ± SD (range) of fibular position* for a group with chronic ankle instability (CAI) (n = 30) and a control group (n = 30).

	CAI Group		Control Group	
Measurement	**CAI Ankle**	**Opposite Ankle**	**Matched Ankle**	**Opposite Ankle**
Fibular position (mm)	14.3 ± 3.1 (7.6-20.3)	16.8 ± 3.4 (8.8-26.8)	16.1 ± 4.6 (11.0-24.0)	16.7 ± 3.3 (11.0-24.0)

* The position of the fibula is defined as the distance between the anterior edge of the distal tibia and anterior edge of the distal fibula, measured with a fluoroscopic image.

TABLE 2. Means ± SD and range of Foot and Ankle Disability Index (FADI) and FADI Sport scores (out of 100%) for both groups.

	CAI Group		Control Group	
	CAI Ankle	**Opposite Ankle**	**Matched Ankle**	**Opposite Ankle**
FADI	90.0 ± 5.1 (79.0-98.0)	99.8 ± 0.4 (92.0-100.0)	99.9 ± 0.2 (99.0-100.0)	99.5 ± 0.6 (99.0-100.0)
FADI Sport	80.3 ± 13.0 (44.0-97.0)	99.7 ± 1.3 (87.5-100.0)	99.7 ± 1.3 (94.0-100.0)	98.6 ± 1.4 (94.0-100.0)

Clinical Pearl #1:

'Unfreeze' the foot and ankle to help restore "ankle strategy"

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Postural control strategies during single limb stance following acute lateral ankle sprain

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ABSTRACT

Background: Single-limb stance is maintained via the integration of visual, vestibular and somatosensory afferents. Musculoskeletal injury challenges the somatosensory system to reweight distorted sensory afferents. This investigation supplements kinetic analysis of eyes-open and eyes-closed single-limb stance tasks with a kinematic profile of lower limb postural orientation in an acute lateral ankle sprain group to assess the adaptive capacity of the sensorimotor system to injury.
Methods: Sixty-six participants with first-time acute lateral ankle sprain completed a 20 second eyes-open single-limb stance task on their injured and non-injured limbs (task 1). Twenty-three of these participants successfully completed the same 20 second single-limb stance task with their eyes closed (task 2). A non-injured control group of 19 participants completed task 1, with 16 completing task 2. 3-dimensional kinematics of the hip, knee and ankle joints, as well as associated fractal dimension of the center-of-pressure path were determined for each limb during these tasks.
Findings: Between trial analyses revealed significant differences in stance limb kinematics and fractal dimension of the center-of-pressure path for task 2 only. The control group bilaterally assumed a position of greater hip flexion compared to injured participants on their side-matched "involved" (7.41 [6.1°] vs 1.44 [4.8]°; $\eta^2 = .34$) and "uninvolved" (9.59 [8.5°] vs 2.16 [5.6°]; $\eta^2 = .31$) limbs, with a greater fractal dimension of the center-of-pressure path (involved limb = 1.39 [0.16°] vs 1.25 [0.14°]; uninvolved limb = 1.37 [0.21°] vs 1.23 [0.14°]).
Interpretation: Bilateral impairment in postural control strategies present following a first time acute lateral ankle sprain.

1. Introduction

Balance is a generic term describing the dynamics of body posture to prevent falling (Winter, 1995). Information about body posture in single-limb stance (SLS) with respect to the force of gravity is provided to the central nervous system by vestibular, visual and somatosensory afferents (McCollum et al., 1996). Redundancies between structurally different sensory afferents [otherwise known as 'degeneracies' (Glazier and Davids 2009)] can combine in a variety of ways to produce similar efferent motor responses; this allows the sensorimotor system to simplify a task within a limited number of movement strategies (Nashner, 1979). Selective reweighting of these degeneracies by the central nervous system is then based on the availability of reliable information (McKeon et al., 2012). As a result, it is possible for the functioning somatosensory system to produce a motor output contingent with maintaining balance in the presence of altered visual, vestibular and/or somatosensory signals (McCollum et al., 1996). Despite this, some deterioration in the efferent response may become evident in simple postural control tasks when sensorimotor afferents are compromised (Winter, 1995).

Kinematic (Huurnink et al., 2014; Liu et al., 2012) and center of pressure (COP) (Prieto et al., 1996) analyses have been previously used to quantify the motor response associated with distorted sensory environments during single limb stance in a variety of populations. The underlying premise of these investigations is that in instances of sensorimotor compromise, the motor apparatus is organized in such a way as to adopt suitable compensatory postural orientation strategies (Pintsaar et al., 1996) which are reflected in the COP path trajectory features. A number of measures are currently available with which to characterize the COP path trajectory. However, traditional measures such as

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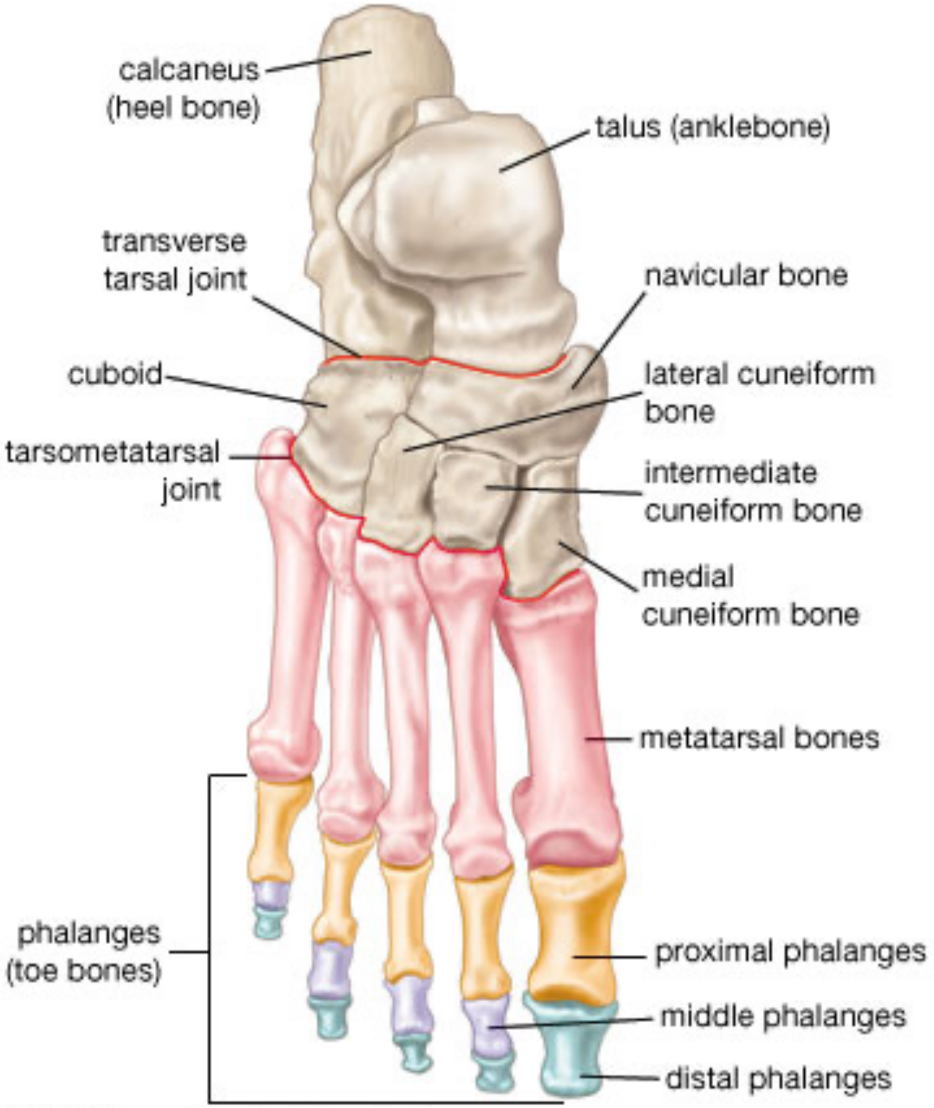
calcaneus
(heel bone)
talus (anklebone)
transverse
tarsal joint
navicular bone
cuboid
lateral cuneiform
bone
tarsometatarsal
joint
intermediate
cuneiform bone
medial
cuneiform bone
metatarsal bones
phalanges
(toe bones)
proximal phalanges
middle phalanges
distal phalanges

Kaltenborn's Test for the Foot and Toes[1]

FIXATE	MOVE	DIRECTION
Midfoot	Toe	Plantar / Dorsal
2nd and 3rd Cuneiforms	3rd Metatarsal	Plantar
2nd and 3rd Cuneiforms	2nd Metatarsal	Plantar
1st Cuneiform	1st Metatarsal	Plantar
Navicular	1st, 2nd, 3rd Cuneiforms	Plantar
Talus	Navicular	Dorsal[2]
Cuboid	4th and 5th Metatarsals	Plantar
Navicular and 3rd Cuneiform	Cuboid	Plantar
Calcaneous	Cuboid	Plantar[2]
Talus	Calcaneous	Plantar[2]

Notes:

[1] Kaltenborn, F.M. (2002). Manual Mobilization of the Joints: The Kaltenborn Method of Joint Examination and Treatment. Volume 1: The Extremities. Oslo: Olaf Norlis Bokhandel. Available through OPTP Minneapolis, Minnesota, USA.

[2] We will modify these directions slightly in class.


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