Physical Therapy in Sport xxx (2013) 1–4

Contents lists available at SciVerse ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

Critical review of self-reported functional ankle instability measures: A follow up

Janet Simon [a,*], Matthew Donahue [b], Carrie L. Docherty [a]

[a] Department of Kinesiology, Indiana University, 1025 E. 7th Street, Bloomington, IN, USA
[b] Department of Health Promotion and Human Performance, Weber State University, Ogden, UT, USA

ARTICLE INFO

Article history:
Received 17 November 2012
Received in revised form
25 February 2013
Accepted 28 March 2013

Keywords:
Identification of Functional Ankle Instability
Ankle Instability Instrument
Cumberland Ankle Instability Tool
Functional ankle instability
Subjective outcome measure

ABSTRACT

Objective: Determine which ankle instability questionnaire predicts subject's ankle instability status based on a minimum accepted criteria for FAI (MC_FAI).
Design: Cross-sectional study.
Setting: Large Midwestern University.
Participants: College aged subjects (n = 1127 19.6 ± 2.1 years) from a university population were recruited for this study. Any volunteer, regardless of ankle injury history was included in the study.
Main outcome measures: The independent variables were the score on three self-report ankle instability questionnaires: Ankle Instability Instrument, Cumberland Ankle Instability Tool, and Identification of Functional Ankle Instability. Subjects completed the questionnaires for their dominant limb during a single testing session. The dependent variable was created based on the previously established MC_FAI. This was established as at least one ankle sprain and at least one episode of giving way. Data were modeled using a chi-square and multinomial logistic regression. 95% confidence intervals were calculated for the resulting odds ratios.
Results: A test of the full model with all three predictors against MC_FAI revealed that only the IdFAI ($X^2 = 457.09$, $p = .001$) had a significant relationship with the outcome variable. The IdFAI had an overall prediction rate of 87.8%.
Conclusions: This analysis illustrates that IdFAI is a good overall option for predicting ankle stability status by self-reported questionnaire.

1. Introduction

Lateral ankle sprains are a very common joint injury, while many of these injuries resolve with conservative treatment a considerable number of individuals develop lasting disabilities (Bosien, Staples, & Russell, 1955; Garrick, 1977; Gerber, Williams, Scoville, Arciero, & Taylor, 1998; Verhagen, 1995). An example of one such disability is functional ankle instability (FAI). The diagnosis of FAI is controversial in both clinical practice and academic literature, but researchers have shown that between 55 and 72% of individuals who sustain a lateral ankle have reported residual symptoms for weeks or years, and/or develop FAI (Braun, 1999; Gerber et al., 1998; Verhagen, 1995). Conventionally, ankle pathologies are diagnosed utilizing clinical skills, imaging techniques and self-reported subjective questionnaires (Fujii, Luo, & Kitaoka, 2000; Tohyama, Yasuda, Ohkoshi, Beynnon, & Renstrom, 2000). Regardless of the technique employed, diagnoses of most orthopedic conditions are a result of a well-accepted test and/or outcome measure. However no test or measure has been globally agreed upon to "diagnose" FAI.

Self-reported questionnaires are frequently utilized to aid in the identification of conditions with specific symptom traits. There are numerous generic health status measures that assess overall health, including social, emotional and physical health (Nelson & Berwick, 1989; Streiner & Norman, 1995). These measures are intended to be used across a broad spectrum of diseases, interventions, and demographic subgroups (Nelson & Berwick, 1989; Streiner & Norman, 1995). Most global measures are time consuming to administer and score, and are not designed for individual patient decision making because they are meant to be utilized for a wide variety of pathologies. Conversely, condition or disease specific measures are designed to assess characteristics that are most relevant to the disease or condition of interest (Nelson & Berwick, 1989; Streiner & Norman, 1995). Ideally, disease specific measures are composed of items that are frequently affected by the condition and that are likely to demonstrate clinically important changes.

* Corresponding author. Tel.: +1 6464830533.
E-mail address: jesimon@indiana.edu (J. Simon).

1466-853X/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ptsp.2013.03.005

Many researchers and clinicians have turned to self-reported questionnaires in order to identify individuals with FAI. There are seven such questionnaires that appear frequently in ankle instability literature (Docherty, Gansneder, Arnold, & Hurwitz, 2006; Eechaute, Vaes, & Duquet, 2008; Hiller, Refshauge, Bundy, Herbert, & Killbreath, 2006; Hubbard & Kaminski, 2002; Martin, Irrgang, Burdett, Conti, & Van Swearingen, 2005; Roos, Brandsson, & Karlsson, 2001; Rozzi, Lephart, Sterner, & Kuligowski, 1999). While some of these questionnaires were designed to detect FAI others are general assessments of lower limb function. Recently, an investigation of these seven instruments, [Ankle Instability Instrument (AII), Ankle Joint Functional Assessment Tool (AJFAT), Chronic Ankle Instability Scale (CAIS), Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Ability Measure (FAAM), Foot and Ankle Instability Questionnaire (FAIQ), Foot and Ankle Outcome Score (FAOS)] found that no single instrument was able to predict if a subject had a history of at least one ankle sprain and an episode of giving way (Donahue, Simon, & Docherty, 2011). These two criteria have long been assumed to be the minimum criteria of someone who has FAI. Interestingly, the statistical model of the seven questionnaires revealed that the combined use of the CAIT ($X^2 = 8.22$ odds ratio = 0.31, 95% CI 0.14, 0.69, $p = .004$) and the AII ($X^2 = 29.70$ odds ratio = 0.10, 95% CI 0.04, 0.23, $p < .001$) had a significant relationship with the minimum criteria for FAI and may be the best option for determining if an individual has FAI (Donahue et al., 2011). However, the use of two instruments that were not inherently designed to be used together, created a lengthy and cumbersome process.

Subsequently, a new instrument specifically designed to detect FAI, the Identification of Functional Ankle Instability (IdFAI), was created (Simon, Donahue, & Docherty, 2012). The IdFAI is a one page self-reported questionnaire based on the CAIT and AII (Docherty et al., 2006) (Hiller et al., 2006). The IdFAI was found to have a distinct discrimination score of 10 when used to identify people who met a minimally accepted criterion for FAI and an overall accuracy of 89.6% (Simon et al., 2012). Further analysis of the IdFAI reveal "excellent" test-retest reliability (ICC = 0.92) (Donahue, Simon, & Docherty, 2012).

We believe the next logical step in the progression of research on self-reported questionnaires is to do a follow up study comparing the IdFAI, CAIT, and AII using the same techniques utilized in the previous investigation (Donahue et al., 2011). The foundation of the current investigation is to compare the newly formed IdFAI to the two instruments originally identified to accurately 'diagnose' individuals with FAI. Therefore, the purpose of this study was to determine which of the three self-reported ankle instability measures accurately identify participants who meet a minimum accepted criterion for FAI.

2. Materials and methods

Participants were recruited from classes at a large Midwestern US university. All participants were enrolled students at the university, and no other specific inclusion criteria were identified. Subsequently participants had a wide range of ankle injury history. No other demographic information was collected regarding physical activity level or previous participation in sports or recreational activity as these questionnaires should apply to any population. The university's institutional review board approved this study.

Subjects were asked to complete the questionnaires for their dominant limb, and all three questionnaires were completed in one in class testing session. Investigators were present for all sessions to answer any questions subjects may have had, each subject completed the questionnaires in a randomized order. Investigators instructed participants to complete all three questionnaires; however, we could not require them to do so. Therefore, some participants filled out the questionnaire incorrectly or failed to answer all questions. Two exclusion criteria were established: individuals with a history of lower limb fracture and individuals who returned incomplete/incorrect questionnaires.

The independent variables were defined as the score on the AII, CAIT, and IdFAI. The dependent variable was created based on the previously established minimum accepted criterion for FAI (MC_FAI) that was obtained from a cover sheet containing other demographic information (age and sex). MC_FAI was established as at least one ankle sprain and at least one episode of giving way (Donahue et al., 2011; Simon et al., 2012). This criterion was initially based on Freeman's work in the 1960's as well as the continual utilization of these items when describing FAI. Freeman described FAI as "the tendency for the foot to 'give way' after an ankle sprain" (Freeman, 1965).

Data were modeled using chi-square and multinomial logistic regression. 95% confidence intervals (CI) were calculated for the resulting odds ratios. Additional statistical analysis included descriptive statistics, frequencies, sensitivity, specificity, odd ratios and relative risk based off of a 2×2 contingency table.

3. Results

One thousand three hundred forty-one participants agreed to fill out the three questionnaires. Two hundred fourteen individuals were excluded from the study. Of these, 101 were excluded for filling out the questionnaire incorrectly, having missing questionnaires, or for incomplete questionnaires. An additional 113 were excluded for having a dominant limb ankle fracture. Subsequently, 1127 participants were available for the data analysis (581 males, 546 females, 19.56 ± 2.05 years). Limb dominance for the cohort was 1026 (91.1%) right limb and 101 (8.9%) left limb dominance. Eight hundred and twenty five individuals (73.2%) had a history of an ankle sprain and 302 individuals (26.8%) had no history of ankle injury. Of the 825 participants who previously sprained their ankle, 247 (29.9%) had sprained only the right ankle, 82 (9.9%) only the left ankle, and 496 (60.1%) had experienced an ankle sprain on both ankles. Of the 825 individuals who had an ankle sprain 289 (35.0%) stated that they experienced episodes of giving way.

A direct logistic regression analysis was performed with FAI status (MC_FAI or no MC_FAI) as the outcome variable and three questionnaires as predictors: AII, CAIT, and IdFAI. Analysis was performed using SPSS Statistics 20.0. The regression model revealed that the IdFAI questionnaire was equally good at determining when a participant did or did not meet the minimum criteria for FAI with an overall percentage of correctness of 87.8%, no MC_FAI = 88.5% and MC_FAI = 87.0%. A test of the full model with all three predictors against MC_FAI revealed that only the IdFAI ($X^2 = 457.09$, $p = .001$) had a significant relationship with the outcome variable. Table 1 shows regression coefficients, Wald Chi square, odds ratios, and 95% confidence intervals for odds ratios for each of the three predictors. According to the Wald criterion, only

Table 1
Regression statistics for the full model.

	B	Wald chi-square	Odds ratio	95% confidence interval for odds ratio		*P*-value significance
				Lower	Upper	
IdFAI	−3.803	353.15	0.022	0.015	0.033	0.001*
CAIT	−0.175	0.643	0.839	0.547	1.288	0.423
AII	−0.272	1.461	0.762	0.490	1.184	0.227
(Constant)	1.648	90.123				

*Significant result ($p < .05$).

Please cite this article in press as: Simon, J., et al., Critical review of self-reported functional ankle instability measures: A follow up, *Physical Therapy in Sport* (2013), http://dx.doi.org/10.1016/j.ptsp.2013.03.005

Table 2
Sensitivity and specificity of predictor variables based on 2 × 2 contingency table.

	Sensitivity (95% CI)	Specificity (95% CI)	Odds ratio (95% CI)	Risk (95% CI)
IdFAI	0.84 (0.81, 0.87)	0.91 (0.88, 0.93)	52.24 (36.56, 74.66)	7.66 (6.19, 9.48)
AII	0.63 (0.57, 0.68)	0.65 (0.62, 0.68)	3.16 (2.38, 4.19)	2.39 (1.93, 2.97)
CAIT	0.66 (0.61, 0.71)	0.72 (0.68, 0.75)	4.98 (3.82, 6.49)	2.87 (2.41, 3.43)

the IdFAI reliably predicted FAI status. Sensitivity, specificity, odds ratio and relative risk with confidence intervals was calculated for the predictor variables (Table 2). Table 3 contains information regarding the 2 × 2 classification table used to calculate sensitivity, specificity, odds ratio and relative risk.

4. Discussion

The results of this study illustrate that the singular use of the IdFAI can significantly predict a minimum criterion of FAI. Previously, when data from the CAIT and the AII were modeled in conjunction, an overall prediction of 84.6% was revealed (Donahue et al., 2011). In the current study, the IdFAI achieved an overall prediction value of 87.8%. This appears to indicate that the singular use of IdFAI has a higher accuracy than the combined use of the AII and CAIT. We believe these results reflect the intended purpose of creating the IdFAI: a simple single page questionnaire, that provides a clear and concise definition of giving way, is quick to administer and score, and specifically designed for use with FAI populations. In addition, sensitivity, specificity, odds ratio, and relative risk have been calculated for the IdFAI and an additional analysis was conducted on all instruments used in our original study (Donahue et al., 2011). Odds ratios are a measure of effect size, that describe the strength of association between two binary data values (Mosteller, 1968). In other words, interpretation of our data indicates that individuals with MC_FAI are 52% more likely to be identified as having FAI on the IdFAI than individuals without MC_FAI. Relative risk is the risk of an event relative to an exposure (Sistrom & Garvan, 2004). It is the ratio of the probability of the event occurring in the exposed group versus the non-exposed group (Sistrom & Garvan, 2004). For most clinicians it is easiest to interpret relative risk to their clinical practice. In the case of our data, individuals with MC_FAI are at an increased "risk" of being identified as having FAI on the IdFAI than individuals without MC_FAI. The results of our research indicate that individuals with MC_FAI are 7 times more likely to be identified as having FAI on the IdFAI than individuals without MC_FAI.

Sensitivity is useful to calculate because it relates to the test's ability to identify positive results (true positives) while taking in consideration the number of false negatives. Specificity relates to the ability of the test to identify negative results (true negative) while taking in consideration the number of false positives identified. The IdFAI has a calculated sensitivity of 0.83 (CI: 0.75; 0.89) and specificity 0.94 (CI: 0.89, 0.97). Using the data from the current study the sensitivity and specificity of the combined use of the AII and CAIT revealed a sensitivity of 0.82 (CI: 0.66; 0.92) and specificity 0.82 (CI: 0.76; 0.87). Table 4 contains the values of sensitivity and specificity for all instruments investigated in this and the previous study conducted on this topic (Donahue et al., 2011). The IdFAI, AII, and CAIT values are from the current study while all other values were calculated from the original study (Donahue et al., 2011). These data illustrates that the IdFAI has higher specificity without compromising sensitivity compared to all instruments including the combined use of the AII and CAIT.

Self-reported subjective questionnaires are currently the most widely accepted methodology utilized to "diagnose" an individual with FAI. Yet information obtained from self-reported questionnaires is only useful if there is evidence to support the use of the instrument as well as the meaningfulness of the obtained score. Our original review of the literature identified seven self-reported instruments that had been previously used in the literature to assess FAI; other researchers have also identified similar instruments to identify FAI (Carcia, Martin, & Drounin, 2008; Donahue et al., 2011; Eechaute, Vaes, Van Aerschot, Asman, & Duquet, 2007). However, one inherent issue with some of the reported instruments is that they were not originally created to assess FAI. Several were initially designed to gather symptoms for the lower leg or identify functional limitations of the lower leg, a summary of this historical information is provided in Table 5.

When we developed the IdFAI we felt it was important to not only design an instrument specifically for the detection of FAI but to address any issues with existing instruments. When collecting data from participants about their FAI status we found that numerous individuals struggled to clearly understand 'giving way' but few actually asked for clarification of the term from the examiners present during data collection. While there are several plausible explanations for this, the end result remains the same; many individuals completed these instruments utilizing an unclear or possibly incorrect definition of 'giving way'. For this reason, we felt it was important to address this source of variability by providing a definition of 'giving way' to the participants at the top of the questionnaire. The specific definition was, 'Giving way' is a temporary uncontrollable sensation of instability or rolling over of one's ankle' (Simon et al., 2012). As a result all individuals were provided the same information instead of guessing what 'giving way' means. While this is only one small step, as some individuals may not thoroughly read the definition we feel providing a 'giving way' definition may be a significant factor in our results indicating the IdFAI is more suitable at "diagnosing" individuals FAI. Future research on the IdFAI should include; an investigation of the effect of instability severity on IdFAI scores, as well as a comparison on how people with FAI and "Copers" score on the IdFAI.

Table 3
Two × two table of classifications.

	IdFAI		AII		CAIT	
	No FAI	FAI	No FAI	FAI	No FAI	FAI
No_MCFAI	601	77	577	101	557	126
MCFAI	62	415	307	170	222	250

Table 4
Sensitivity and specificity for all FAI instruments.

	Sensitivity (95%CI)	Specificity (95%CI)
IdFAI[a]	0.83 (0.75–0.89)	0.94 (0.89–0.97)
AII & CAIT[a]	0.82 (0.66–0.92)	0.82 (0.76–0.87)
AII[a]	0.73 (0.59–0.83)	0.85 (0.79–0.83)
CAIT[b]	0.56 (0.45–0.67)	0.86 (0.79–0.90)
FAAM[b]	0.59 (0.48–0.74)	0.78 (0.72–0.83)
FAOS[b]	0.56 (0.35–0.75)	0.76 (0.69–0.81)
AJFAT[b]	0.18 (0.05–0.41)	0.77 (0.71–0.83)
CAIS[b]	0.41 (0.21–0.63)	0.75 (0.69–0.81)
FAIQ[b]	0.06 (0.01–0.33)	0.75 (0.69–0.80)

[a] Calculated from current data set.
[b] Calculated from: Donahue M., Simon J., & Docherty C. (2011). Critical review of self-reported functional ankle instability measures. *Foot Ankle Int.*, 32, 1140–1146.

Please cite this article in press as: Simon, J., et al., Critical review of self-reported functional ankle instability measures: A follow up, *Physical Therapy in Sport* (2013), http://dx.doi.org/10.1016/j.ptsp.2013.03.005

Table 5
Historical information related to previously published self-reported questionnaire used in the functional ankle instability literature.

	Originally intended use
Ankle Instability Instrument	Identify individuals with functional ankle instability (Docherty et al., 2006)
Ankle Joint Functional Assessment Tool	Evaluate the ankle joint's performance during functional activities and document subjective changes following an ankle intervention (Rozzi et al., 1999)
Cumberland Ankle Instability Tool	Identify and grade functional ankle instability (Hiller et al., 2006)
Chronic Ankle Instability Scale	Multidimensional instrument for Chronic Ankle Instability (Eechaute et al., 2008)
Foot and Ankle Ability Measure	Developed from the Foot and Ankle Disability Index (FADI) which was initially created to assess functional limitations related to general foot and ankle conditions (Martin et al., 2005)
Foot and Ankle Outcome Score	Developed to evaluate symptoms and functional limitations related to general foot and ankle conditions (Roos et al., 2001)
Foot and Ankle Instability Questionnaire	Designed to rule out MAI and identify FAI (Hubbard & Kaminski, 2002)
Identification of Functional Ankle Instability	Created to specifically diagnose FAI based on a minimum acceptable criteria for FAI (Simon et al., 2012)

5. Conclusion

Interpretation of the results from the current study demonstrates that the IdFAI can accurately predict if an individual meets the minimum criterion for FAI. The IdFAI has also demonstrated improved overall predication scores over the self-reported questionnaires currently in use. Therefore, while further research is still necessary, we recommend the use of the IdFAI for both clinicians looking to easily identify individuals with FAI related deficits as well as researchers looking to create homogenous samples of individuals that can be more easily compared across research groups.

Conflict of interest
None declared.

Ethical approval
The university's institutional review board approved this study.

Funding
None declared.

References

Bosien, W., Staples, O., & Russell, S. (1955). Residual disability following actue ankle injuries. *Journal of Bone and Joint Surgery, 37-A*, 1237–1243.
Braun, B. (1999). Effects of ankle sprain in a general population 6 to 18 months after medical evaluation. *Archives of Family Medicine, 37*, 280–285.
Carcia, C., Martin, R., & Drounin, J. (2008). Validity of the foot and ankle ability measure in athletes with chronic ankle instability. *Journal of Athletic Training, 43*, 179–183.
Docherty, C., Gansneder, B., Arnold, B. L., & Hurwitz, S. (2006). Development and reliability of the ankle instability instrument. *Journal of Athletic Training, 41*, 154–158.
Donahue, M., Simon, J., & Docherty, C. (2011). Critical review of self-reported functional ankle instability measures. *Foot & Ankle International, 32*, 1140–1146.
Donahue, M., Simon, J., & Docherty, C. (2012). Reliability and validity of a new questionnaire created to establish the presence of functional ankle instability: the IdFAI. *Athletic Training and Sports Health Care, 5*, 38–43.
Eechaute, C., Vaes, P., & Duquet, W. (2008). The chronic ankle instability scale: clinimetric properties of a multidimensional, patient-assessed instrument. *Physical Therapy in Sport, 9*, 57–66.
Eechaute, C., Vaes, P., Van Aerschot, L., Asman, S., & Duquet, W. (2007). The clinimetric qualities of patient-assessed instruments for measuring chronic ankle instability: a systematic review. *BMC Muscloskeletal Disorders, 8*.
Freeman, M. (1965). Instability of the foot after injuries to the lateral ligament of the ankle. *Journal of Bone & Joint Surgery (British Volume), 47b*, 669–677.
Fujii, T., Luo, Z., & Kitaoka, H. (2000). The manual stress test may not be sufficent to differetiate ankle ligament injuries. *Clinical Biomechanics, 15*, 619–623.
Garrick, J. (1977). The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *American Journal of Sports Medicine, 5*, 241–242.
Gerber, J., Williams, G., Scoville, C., Arciero, R., & Taylor, D. (1998). Persistent disability associate with ankle sprains: a prospective examination of an athletic population. *Foot & Ankle International, 19*, 653–660.
Hiller, C., Refshauge, K., Bundy, A., Herbert, R., & Killbreath, S. (2006). The Cumberland ankle instability tool: a report of validity and reliability testing. *Archives of Physical Medicine and Rehabilitation, 87*, 1234–1241.
Hubbard, T., & Kaminski, T. (2002). Kinesthesia is not affected by functional ankle instability status. *Journal of Athletic Training, 37*, 481–486.
Martin, R. L., Irrgang, J. J., Burdett, R., Conti, S., & Van Swearingen, J. M. (2005). Evidence of validity for the foot and ankle ability measure(FAAM). *Foot & Ankle International, 26*, 968–983.
Mosteller, F. (1968). Association and estimation in contingency tables. *Journal of the American Statistical Association, 63*, 1–28.
Nelson, E., & Berwick, D. (1989). The measurement of health status in clinical practice. *Medical Care, 27*, S77–S90.
Roos, E., Brandsson, M., & Karlsson, J. (2001). Validation of the foot and ankle outcome score. *Foot & Ankle International, 22*, 788–794.
Rozzi, S., Lephart, S., Sterner, R., & Kuligowski, L. (1999). Balance training for persons with functionally unstable ankles. *Journal of Orthopaedic & Sports Physical Therapy, 29*, 478–486.
Simon, J., Donahue, M., & Docherty, C. (2012). Development of the identification of functional ankle instability. *Foot & Ankle International, 33*, 755–763.
Sistrom, C., & Garvan, C. (2004). Proportions, odds, and risk. *Radiology, 230*, 12–21.
Streiner, D., & Norman, G. (1995). *Health measurement scales: A practical guide to their development and use*. Oxford, England: Oxford University Press.
Tohyama, H., Yasuda, H., Ohkoshi, Y., Beynnon, B., & Renstrom, P. (2000). Anterior drawer test of acute talofibular ligament injuires of the ankle: how much load should be applied during the test? *American Journal of Sports Medicine, 2003*, 226–232.
Verhagen. (1995). Long-term follow-ip of inversion trauma of the ankle. *Archives of Orthopaedic Trauma Surgery, 114*, 92–96.

Please cite this article in press as: Simon, J., et al., Critical review of self-reported functional ankle instability measures: A follow up, *Physical Therapy in Sport* (2013), http://dx.doi.org/10.1016/j.ptsp.2013.03.005