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Purpose To cross-culturally adapt the Identification of Functional Ankle Instability (IdFAI) for use with Korean-speaking participants. **Methods** The English version of the IdFAI was cross-culturally adapted into Korean based on the guidelines for the process of cross-cultural adaptation of a self-report questionnaire. The psychometric properties in the Korean version of the IdFAI (IdFAI-K) were measured for test-retest reliability, internal consistency, criterion-related validity, discriminative validity, and measurement error in 181 native Korean-speakers. **Results** Intra-class correlation coefficients ($ICC_{2,1}$) between the English and Korean versions of the IdFAI for test-retest reliability was 0.98 (standard error of measurement [SEM] = 1.41). The Cronbach's alpha coefficient was 0.89 for the IdFAI-K. The IdFAI-K had a strong correlation with the SF-36 (r_s = -0.69, p< 0.001) and the CAIT-K (r_s = -0.65, p< 0.001). The cut-off score of 10 was the optimal cut-off score to distinguish between the group memberships. The minimally detectable change (MDC) of the IdFAI-K score was 3.91. **Conclusion** The IdFAI-K has shown to be an excellent and highly reliable and valid. Therefore, the IdFAI-K can be utilized to assess the presence of Chronic Ankle Instability (CAI) by researchers and clinicians working among Korean-speaking populations.

Keywords: patient report outcome, validity, reliability, translation, Korean version.

Introduction

Chronic ankle instability (CAI) is a common musculoskeletal issue resulting from lateral ankle sprain(s).[1] Approximately 40% of patients with a history of lateral ankle sprains and/or instability (the sensation of "giving way") will develop CAI.[2, 3] Patient report outcome (PRO) questionnaires, also known as self-reported outcome questionnaires, have been primarily utilized to identify the perception of dysfunction and severity of CAI as a subjective clinical measure.[4, 5, 6] Applying a PRO with specific cut-off scores has been recommended as a criterion to assist with return-to-play decision making regarding ankle sprains and the presence of perceived ankle instability.[4, 7] Many reliable and valid PRO questionnaires have been developed to determine patient-reported ankle instability.[8, 9, 10, 11]

The International Ankle Consortium[4] recommend the use of PRO questionnaires with validated specific cut-off scores such as Ankle Instability Instrument (AII)[8], Cumberland Ankle Instability Tool (CAIT)[3], and Identification of Functional Ankle Instability (IdFAI)[11] for evaluating self-reported ankle instability in individuals with CAI. The CAIT has been validated and widely utilized to identify patients with CAI in clinical and research settings.[4, 9, 12] The CAIT has also been cross-culturally adapted and translated in Korean[5], Brazilian-Portuguese[13], Spanish[14], Persian[15], Dutch[16], and Japanese[17]. Specifically, the CAIT Korean version (CAIT-K) demonstrated high content validity and reliability for use in Korean-speaking populations with CAI.[5] Simon et al.[11] designed the IdFAI to determine the severity of ankle instability in individuals with CAI with specific cut-off scores. It was originally developed in English and demonstrated excellent validity (Receiver Operating Characteristic [ROC] curve range 0.88 – 0.94) and reliability (Intra-class

Correlation [ICC2,1]: 0.92 – 0.98).[11, 18] The precision of the IdFAI is the culmination of combining the main advantages of the AII and CAIT to clearly define the historical CAI symptom of "giving way" in individuals with CAI.[11] Also, it is redundant to administer the IdFAI as a singular PRO in both clinical and research settings.[11]

However, currently the CAIT is the only validated PRO to assess the severity of ankle instability in a Korean population even though using multiple PROs has been recommended to better characterize deficits in individuals with CAI.[19] Therefore, the purpose of this study was to cross-culturally translation and adaptation of the IdFAI into the Korean language and the validation of the IdFAI in the Korean-speaking population with CAI.

Methods

The Identification Functional Ankle Instability (IdFAI)

The English version of the IdFAI (original version) was developed to combine the AII[8] and the CAIT[9], to best predict the minimum criteria to classify an ankle instability group.[11] The IdFAI consists of 10 items to focus on the history of ankle sprains, the presence and severity of ankle instability, and the functional performance in daily living and other physical activities.[11] The minimum score is 0 with a higher scores indicating decreased ankle function. However, there is no maximum score due to item 1, which asks for the number of ankle sprains in the blank (possible maximum score from item 2 to 10 is 37) in contrast with the AII and CAIT.[11] The original IdFAI was established with a cut-off score of ≤ 10 to identify individuals without CAI while individuals with a score of 11 or higher were likely to have CAI.[11]

Cross-cultural adaptation procedures

All cross-cultural adaptation and validation procedures of the Korean version of the IdFAI (IdFAI-K) were performed based on the established cross-cultural adaptation guidelines.[20, 21] In addition to following the guidelines, an additional step (step V) of confirming the accuracy of wording and item understanding was added to develop well-translated language from English to Korean.[5] Korean is a relatively homogenous language with a few regional dialects, which are understandable to one another.[5, 22] The standard Korean, Seoul dialect (accent), was applied for translation in the current study.[22]

- *Step I:* The co-investigator who was fluent in Korean and English versions of the IdFAI translated it into Korean.
- *Step II:* The first translated Korean version of the IdFAI from step I was independently reviewed and proofread by four bilingual experts (native Korean-speakers [two certified athletic trainers, one biomechanist, and one physical educator]). A preliminary IdFAI-K was developed through a consensus review.
- *Step III:* Backward-translation was performed to translate a preliminary IdFAI-K into English by two native English-speakers who were born in the U.S. and raised by Korean-speaking parents. Two native English-speakers were blinded to the English version of the IdFAI and had no medical knowledge.
- *Step IV:* All bilingual experts and investigators confirmed that there were negligible differences after comparing the English version of the IdFAI and the backward-translation version of the IdFAI.
- *Step V:* The English versions of the IdFAI and the IdFAI-K were administered to 23 bilingual panelists who were enrolled in a large university in the U.S. as a student, or had earned an academic degree from an institution in the U.S.[5] The

final version of the IdFAI-K was developed after resolving all discrepancies based on feedback (the translation, semantic, idiomatic, and experiential equivalencies) from 23 bilingual panelists though a consensus review.[5]

- *Step VI:* The final version of the IdFAI-K was administered to 181 participants who were native Korean-speakers with and without the symptoms of CAI at a large university in Seoul, South Korea, for testing the reliability and validity (construct and criterion) of the IdFAI-K.

Participants

A total of 181 native Korean-speakers were involved in the current study. All native Korean-speakers were national-level athletes who had participated in practice and competitions in multiple Olympic sports (boxing, 21; fencing, 22; wrestling, 19; judo, 23; field hockey, 23; taekwondo, 18; weightlifting, 26; track, 10; and swimming, 19). The inclusion criteria for the native Korean-speakers included a) being between 18 to 35 years of age, b) speaking Korean as a first language, and c) participating in physical activities for ≥ 90 minutes per week.[4, 5] The exclusion criteria included a) bilateral ankle instability, b) a history of surgery and/or fracture in lower extremity, c) a history of lower extremity injury within three months prior to the current study, d) a history of vestibular disorder, Charcot-Marie-Tooth disorder, Ehlers-Danlos, or other hereditary nerve, balance, or connective tissue disorders.[4, 5]

Participants were initially classified into 2 groups—either CAI (73 participants) or control (108 participants)— based on the inclusion and exclusion criteria and an injury history questionnaire.[4, 23] The CAI group had a history of moderate to severe lateral ankle sprain(s) which led to at least 3 days of partial or non-weight bearing, and/or a history of "giving way" with physical activity.[4, 23] The control group had no

history of ankle sprains and “giving way.”[5] All participants completed the IdFAI-K in the first session. After 7 days from the first session, participants completed the IdFAI-K again as a second session. In addition to the IdFAI-K, the 36-item short-form health survey (SF-36)[24, 25] was administered to all participants in this study.[5] Participant demographics including age, gender, height, and weight were also collected.

A single researcher, who was blinded to PRO scores during the data collection phase, independently completed all data collection. This study was approved by the Institutional Review Board (IRB) at a large university (Protocol ID#STUDY00000005). The approved informed consent form was obtained from each participant.

Statistical Analysis

The Statistical Package for the Social Science™ 24.00 (SPSS, Inc., Chicago, IL, USA) was utilized to perform all statistical analyses in this study. The independent sample t-test ($\alpha<0.05$) was performed to compare demographics and IdFAI-K scores between the CAI and control groups.

Test-retest reliability

Test-retest reliability was assessed with an intra-class correlation coefficient (ICC2,1). The IdFAI-K was administered twice with a 7-day interval and results were assessed to determine the test-retest reliability. The reliability was interpreted as weak (0.00 – 0.40), moderate (0.41 – 0.75), substantial (0.76 – 0.90), and excellent (0.91 – 1.00).[26]

Internal consistency

Cronbach’s alpha (α) was conducted to determine the internal consistency of the IdFAI-K. A PRO is considered internally consistent when the items are moderately

correlated with each other and with the total score (Cronbach's $\alpha = 0.70 – 0.95$).[26] The score of the first administered IdFAI-K was used for this analysis.[5]

Criterion-related validity

Criterion-related validity of the IdFAI-K was assessed using the Spearman's rank correlation coefficient between the IdFAI-K and SF-36.[5] Additionally, the CAIT-K, which has been previously validated [5, 8], was also used to calculate the Spearman's rank correlation coefficient between the IdFAI-K and the CAIT-K. The correlation coefficient (r_s) was interpreted as weak (0.00 – 0.30), moderate (0.31 – 0.59), and strong (0.60 – 1.00).[26]

Discriminative validity

A discriminant function analysis was conducted to identify a cut-off score of the IdFAI-K, which may discriminate between individuals with and without CAI. To determine the cut-off score of the IdFAI-K, a receiver operating characteristic (ROC) curve was utilized to calculate the Youden index and the area under curve (AUC).[27]

Measurement error

The standard error of measurement (SEM) was calculated as measurement error.[28] In addition to the SEM, the minimal detectable change (MDC) was also calculated ($MDC = 1.96 \cdot \sqrt{2} \cdot SEM$).[29]

Results

Of the 289 native Korean-speakers originally assigned to participate in this study, 15 participants were initially excluded based on the inclusion and exclusion criteria.[4, 5] Fifty-two participants were lost to follow up and/or injured during the data collection period. Additionally, 41 participants were lost due to incomplete and/or misinformed PROs. Thus, a total of 181 participants completely participated in all data

collection procedures from the beginning to the end of the study period. Seventy-three participants were classified into the CAI group and 108 participants were classified into the control group based on the inclusion criteria.[4, 5, 23] All participant recruitment procedures are shown in Figure 1.

There were no statistically significant differences in participants' demographics including age and gender between the CAI and control groups (Table 1). However, there was a statistically significant difference in the IdFAI-K scores (both the first and second administered) between the CAI and control groups (P<0.001) (Table 1).

Reliability

Test-retest reliability

In the CAI group, the intra-class correlation coefficient ($ICC_{2,1}$) between the first administered IdFAI-K (21.47±8.16) and the second administered IdFAI-K (21.22±8.12) was excellent (0.99; [SEM = 0.98]). In the control group, the intra-class correlation coefficient (ICC2,1) between the first administered IdFAI-K (5.00±3.89) and the second administered IdFAI-K (4.31±4.02) was substantial (0.84;[SEM = 1.62]).

Internal consistency

Cronbach's alpha for the IdFAI-K score was 0.89. There was no significant improvement as each item was deleted. However, a slight increase was observed when item 8 was omitted from the scale (Table 2).

Validity

Criterion-related validity

The IdFAI-K showed statistically significant Spearman correlation with the physical health component of the SF-36 (r_s = -0.69, p< 0.001) and the CAIT-K (r_s = -0.65, p< 0.001) as shown in Figure 2.

Discriminative validity

The mean and standard deviation of the IdFAI-K were 21.5±8.2 in the CAI group and 5.0±3.9 in the control group. Additionally, all discriminative (diagnostic) values including sensitivity (Sn), 1-specificity (1-Sp), specificity (Sp), Younden's index (J), positive likelihood ratio (LR+), negative likelihood ratio (LR-), and odds ratios (OR) are shown in Table 3. The maximum Youden index (0.77) for the IdFAI-K was calculated to determine the cut-off score (the IdFAI score of 10), which distinguishes between the groups. The ROC curve had an AUC of 9.2 and indicated that the IdFAI-K was able to significantly discriminate between the groups, as can be seen in Figure 3.

Measurement error

The SEM and MDC of the IdFAI-K score were 1.41 and 3.91, respectively.

Discussion

The most important finding was that the IdFAI-K showed excellent reliability and moderate validity. The IdFAI-K also showed the same cut-off score (the score of 10) to properly identify individuals with CAI as in the original IdFAI. The original English version IdFAI was translated into Korean (the IdFAI-K) and then the cross-cultural adaptation for the IdFAI-K was successfully completed for use in a Korean-speaking population in the current study. It was determined that the translation adequately corresponded with the original English version. The original meanings of the items were preserved in the translation. As the expert panellists reached a complete consensus regarding the final version, no modifications were necessary.

Reliability

Test-retest reliability of the IdFAI-K between the first and second administration was excellent ($ICC_{2,1}$=0.99) and substantial (0.84) in the CAI and control group, respectively.[25] The test-retest reliability of the English version of the IdFAI[11] was 0.92, which is very similar to that of the current study. In addition to the IdFAI, the CAIT has already been cross-culturally adapted in many different languages including Korean (0.94)[5], Dutch (0.94)[30], Japanese (0.83)[17], Brazilian Portuguese (0.95)[13], and Spanish (0.98)[14]. Therefore, the IdFAI-K also demonstrated higher and/or similar test-retest reliability in both the CAI and healthy control population compared to previous studies.

There was no significant improvement as each item was omitted with 0.89 of Cronbach's α coefficient for the IdFAI-K, which is slightly inferior to the internal consistency of the English version (0.96).[11] However, the values from the current study are still classified as moderately correlated (Cronbach's α = 0.70 – 0.95).[25] There was a slight improvement with the omission of item 8 from the scale (Table 2). Item number 8 in the IdFAI-K is a question regarding how long the patient takes to return to normal after ankle injury, which was developed based on item number 9 in the CAIT-K.[5] The cross-cultural adaptation study for the CAIT-K also reported that the Cronbach's α was slightly increased when item 9 was deleted due to the sample populations who had an altered perception and/or were highly trained the same as in the current study.

Overall, the test-retest reliability and internal consistency of the IdFAI-K are considered excellent and present a high level of reliability. Therefore, the IdFAI-K may be considered as a reliable and stable instrument for the Korean-speaking population with CAI.

Validity

The Spearman correlation coefficient between the physical health component of the SF-36 and the IdFAI-K was applied to assess Criterion-related validity. In addition to the SF-36, criterion validity was also assessed between the CAIT-K and IdFAI-K using the Spearman correlation coefficient. The IdFAI-K had a strong correlation with the SF-36 (r_s = -0.69, p< 0.001) and the CAIT-K (r_s = -0.65, p< 0.001), as shown in Figure 2. In the previous study[5], the CAIT-K also showed similar to the Spearman correlation coefficient (r_s = 0.70, p< 0.001) with the physical health component of the SF-36. Therefore, the IdFAI-K is validated to evaluate self-reported ankle instability in Korean-speaking populations. Additionally, the IdFAI has the main advantages of the CAIT: clear identification of the symptoms of CAI and easy administration. The current cross-cultural adaptation and validation study for Korean-speaking populations may be a milestone in CAI research based on the International Ankle Consortium's strong recommendation of using both the CAIT and IdFAI for assessing self-reported ankle instability.[4, 5]

The current ROC curve in Figure 3 was significant (ACU = 0.92). The maximum Younden index value (0.77) indicated that the IdFAI-K score of 10 was the ideal cut-off to accurately discriminate between the CAI and control groups. At the cut-off score of 10, both sensitivity (0.80) and specificity (0.96) were high, as shown in Table 3. The LR+ value was 21.7 and the LR- was 0.20. The original English version of IdFAI[11] showed that a score of 10 was the cut-off to distinguish between participants with and without a history of ankle sprain. Also, the high sensitivity (0.83) and specificity (0.94), LR+ (13.83), and LR- (0.18) of the original IdFAI were calculated at a cut-off score of 10.[11] The IdFAI-K showed exactly the same cut-off score of 10 as

the original English version of the IdFAI.[11] Therefore, the cut-off score of the IdFAI-K can be applied to determine the severity of ankle instability, as in the English version of the IdFAI.

The minimally detectable change (MDC) of the IdFAI-K score was 3.91 points. This result indicates that approximately 4 points is the score change needed to indicate a change in patient complaints. It must be noted that the IdFAI-K subjectively measures experienced ankle instability. However, it was not possible to compare the MDC to that reported in previous studies, as this current study is the first to evaluate the MDC for the IdFAI.

Study limitations

The current study has several limitations as well. The majority of participants were highly trained athletes. This might cause a perception bias on answering the questionnaire due to altered opinion. A variety of background and activity levels are necessary in future studies. Also, the reliability of the IdFAI-K needs to be measured in different age groups.

Conclusion

The Korean version of the IdFAI has been shown to be a valid and reliable PRO for assessing CAI in Korean-speaking populations. Therefore, clinicians and researchers can utilize the IdFAI-K to assess the presence or absence of CAI with the ideal cut-off score of 10. The IdFAI-K can also be easily applied and can provide clinicians and researchers with immediate and correct assessment of the severity of ankle instability in Korean-speaking populations.

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