

## Original Article

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# Reliability and Recalibration of the Persian Version of Cumberland Ankle Instability Tool Cut-off Score in Athletes with Functional Ankle Instability

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## Abstract

**Introduction:** The Cumberland Ankle Instability Tool (CAIT) is a valid instrument for determining the presence and severity of functional ankle instability. This questionnaire was recently cross-culturally adapted into Persian; however, the reliability of the Persian version has not been examined in athletes. CAIT has also been used with various independently-selected cut-off scores to determine instability.

**Objective:** The present study was conducted to evaluate the psychometric properties of the Persian version of CAIT and to determine its optimal cut-off score in athletic populations.

**Method:** One-hundred and sixteen athletes (volleyball, basketball and track and field players) over 18 years old both with and without ankle instability completed the Persian version of the CAIT. The internal consistency, test-retest reliability and discriminative ability of the tool were assessed. A receiver operating characteristic (ROC) curve was drawn to confirm the cut-off point of the Persian version of CAIT using the Youden index.

**Results:** The average CAIT score was 25.14±4.98 for the right and 25.76±4.94 for the left ankle. The Persian version of CAIT had a good internal consistency (Cronbach's  $\alpha$  of 0.78 for the right ankle and 0.79 for the left ankle) and substantial reliability (ICC<sub>2,1</sub> = 0.88; 95% CI: 0.86 – 0.90) in athletes. No ceiling or floor effects were observed. The optimal cut-off score for discriminating between athletes with and without FAI was 24.

**Conclusion:** The Persian version of CAIT was shown to be a reliable tool for assessing functional ankle instability among Iranian athletes.

**Key words:** Ankle Injuries; Athletes; Joint Instability; Patient Acuity; Reproducibility of Results

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## INTRODUCTION

Ankle sprain is one of the most common injuries occurring not only in sports, but in daily activities as well (1-2). It is a particularly common injury in sports with repetitive cutting maneuvers, landings or frequent jumps, such as volleyball and basketball (3). One of the consequences of ankle sprain is Chronic Ankle Instability (CAI), which can be mechanical, functional or both (4-5). Functional Ankle Instability (FAI) is a common consequence of ankle sprain that is characterized by symptoms of giving way, weakness, pain and impaired function (4, 6-7). FAI has been reported in 32 to 47% of patients with a history of ankle sprain (1). It is a well-known fact that ankle sprain and FAI, more in particular, are a significant health risk in the athlete population. Individuals with FAI have a greater risk of injury because of their poor postural control, balance and proprioception (1, 3, 8). There is a real

need for the assessment of FAI as accurately as possible because it is one of the recalcitrant consequences of ankle sprain.

The Cumberland Ankle Instability Tool (CAIT), first published by Hiller et al. in 2006 (4), is a discriminative questionnaire that has been widely used in studies on ankle instability and translated into multiple languages (2, 8-11). This nine-item questionnaire enables classification on a scale from 0 to 30, with higher scores indicating a higher stability. The validity and reliability of the original version of CAIT have been proven (4).

The reliability and validity of the Persian version of CAIT were recently demonstrated in Iran (10-11). Nonetheless, the reliability of its Persian version remains uninvestigated in high-demand athletes. Additionally, CAIT has formerly been used in studies with various independently-selected cut-

off scores to determine instability and this aspect is still vague (4-5, 7,12).

The present study was therefore conducted to evaluate the reliability of the Persian version of CAIT and determine its cut-off score in athletic populations.

## METHODS

### Study design

The present cross-sectional study administered the Persian version of CAIT to the subjects. The subjects were recruited from two sports clubs and two physiotherapy clinics in Tehran, Iran. The study design was approved by the Ethics Committee of Tehran University of Medical Sciences in Tehran, Iran. All the subjects signed a written informed consent prior to completing the questionnaire.

### Definition

The English CAIT is a nine-item questionnaire intended to identify and grade the severity of functional ankle instability. The CAIT items focus on the symptoms of instability during various types of physical activities. The questionnaire has a total score of 0 to 30 for each foot, in which 0 means severe instability and 30 represents normal stability. Original research has established a cut-off score of 27 for discriminating between FAI and non-FAI. The founding authors reported excellent test-retest reliability for this tool (ICC = 0.96), which can discriminate between stable and unstable ankles (4).

### Study populations

Subjects over 18 years old were eligible. To ensure that both people with and without ankle instability entered the study, the subjects were divided into two groups. Group 1 (n = 58) consisted of subjects with or without a history of ankle sprain but who were not looking for treatment for ankle sprain; they may or may not have had episodes of giving way and were recruited mostly from physiotherapy clinics. Group 2 (n = 58) had experienced at least one ankle sprain over the last two months and a feeling of giving way or chronic pain in their ankle joint during exercise or daily activities. The subjects in this group were volleyball, basketball and track and field players (42 professionals and 16 nonprofessionals) who were seeking treatment for ankle sprain. The participants with other lower limb injuries within the previous six months were excluded from the study. A subgroup of group 2 completed the Persian version of CAIT three weeks later for retesting.

### Analysis of the psychometric properties

The internal consistency, test-retest reliability, discriminative ability and potential ceiling and floor effects of the Persian version of CAIT were investigated. The psychometric properties were analyzed separately for each ankle in terms of internal consistency and test-retest reliability. For internal consistency and discriminative ability, the scores from the first administration of the test were used for all the participants. To determine whether a ceiling or floor effect occurred, the scores were extracted from the participants in group 1 who reported having a history of at least one ankle sprain and their data were pooled with those from group 2. For this analysis, the scores of the first round of tests from the ankle with a history of sprain were used. When the participants reported bilateral ankle sprains, one ankle was randomly selected to be analyzed.

The internal consistency of the Persian version of CAIT was assessed using the Cronbach's  $\alpha$ . For this analysis, the CAIT scores obtained from all the participants on the first test were used. An instrument is considered internally consistent when its items are at least moderately correlated with each other and each item is correlated with the total score as well (scores 0.70-0.95 indicate a good internal consistency) (13).

The test-retest reliability of the Persian version of CAIT was determined using the Intraclass Correlation Coefficient (ICC2, 1). For this analysis, the participants from group 2 completed the questionnaire on two occasions at an interval of three weeks. Reliability is supposed to be poor when ICC <0.40, moderate when ICC is between 0.40 and 0.75, substantial when between 0.75 and 0.90 and excellent when >0.90 (13). Agreement between the repeated measurements was calculated using the Standard Error of the Mean (SEM). The Minimal Detectable Change (MDC) was also calculated. The following equations were used to calculate SEM and MDC:  $SEM = SD \times \sqrt{1-ICC}$ ,  $MDC = SEM \times \sqrt{2}$ .

Discriminative ability was assessed to determine whether the Persian version of CAIT could distinguish between athletes with and without FAI. A Receiver Operating Characteristic (ROC) curve was drawn to confirm the cut-off point of the Persian version of CAIT using the Youden index (8). After calculating the diagnostic sensitivity and specificity for each potential cut-off score, the ideal cut-off point was determined using the maximum Youden index, which was calculated as [sensitivity+ (specificity-1)].

Potential ceiling and floor effects for the Persian version of CAIT were determined by calculating the

**Table 1:** the demographic and clinical characteristics of the study participants

| Characteristics        | Group 1<br>(n=58) | Group 2<br>(n=58) | Total<br>(n=116) |
|------------------------|-------------------|-------------------|------------------|
| Age (mean±SD*)         | 27.75±8.07        | 25.63±9.06        | 26.69±8.68       |
| Sex                    |                   |                   |                  |
| Female [n(%)]          | 23 (39.6)         | 24 (41.4)         | 47 (40.5%)       |
| Male [n(%)]            | 35 (60.4)         | 34 (58.6)         | 69 (59.5%)       |
| Height (cm)            | 176.73±10.24      | 175.98±7.86       | 176.36±9.1       |
| Weight (Kg)            | 74.43±16.1        | 72.57±12.68       | 73.5±14.6        |
| CAIT score Right ankle | 26.73±4.23        | 23.56±5.19        | 25.14±4.98       |
| CAIT score Left ankle  | 27.07±3.96        | 24.49±5.48        | 25.76±4.94       |

percentage of subjects who had the minimum and maximum possible scores. The ceiling or floor effect of an instrument potentially affects its validity and reliability as well. A ceiling and floor effect occurs if over 15% of the participant's final score falls on the lowest or highest possible total score (13). For the Persian version of CAIT, a ceiling effect was expected if the questionnaire was completed by subjects with no history of ankle sprain or instability. Potential ceiling and floor effects for the CAIT scores of the first round of tests were therefore investigated in all the subjects in both groups with a history of ankle sprain. When the participants reported a history of bilateral ankle sprain, a random ankle was selected for assessment.

#### Statistical analysis

IBM SPSS Statistics, Version 22 was used for the statistical analyses.

#### RESULTS

A total of 116 participants answered the Persian version of CAIT. Their mean age was 26.69±8.68 years and 69 (59.5%) were male. Table 1 presents the demographic and clinical characteristics of the study participants.

In group 1, 37 participants reported having had at least one ankle sprain, but only eight (21.62%) reported the feeling of giving way. In group 2, all the participants reported having had at least one ankle sprain more than two months prior to completing the questionnaire, and 30 (51.72%) reported the feeling of giving way and 42 (72.41%) reported pain in the ankle joint.

#### Internal Consistency

The scores of the Persian version of CAIT from the first round of tests generated a Cronbach's  $\alpha$  of 0.78 (0.71-0.83) for the right ankle and 0.79 (0.72-0.84) for the left ankle, which indicate a good internal consistency.

#### Test-Retest Reliability

To determine the test-retest reliability, the CAIT scores of group 2 (n=30) were examined. The

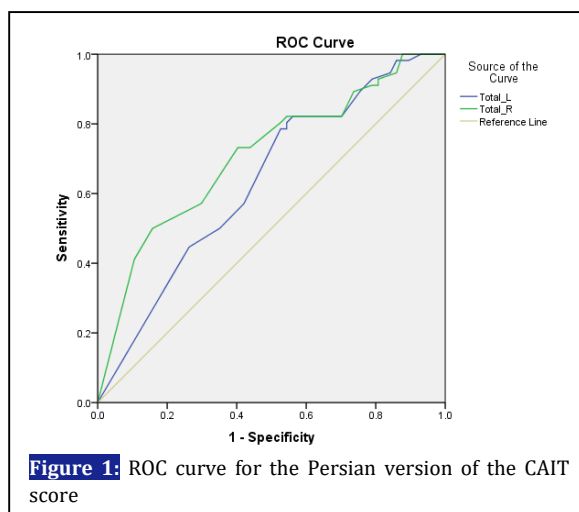
Persian version of CAIT had a substantial reliability for both the left and right ankles (ICC<sub>2,1</sub> = 0.88; 95% CI: 0.86 – 0.90). For the right ankle, the mean scores of the first and second rounds of tests were 23.56±5.19 and 23.17±5.38, respectively, indicating a mean difference of 0.39 (0.19) in the CAIT score. For the left ankle, the mean score in the first and second rounds of tests were 24.49±5.48 and 23.43±5.72, respectively, indicating a mean difference of 1.06 (0.24) in the CAIT score. The SEM and MDC of CAIT were 3.71 and 5.25 for the right ankle and 3.74 and 5.29 for the left ankle.

#### Discriminative Ability

After calculating the ROC curve (figure 1), the largest Youden index value [sensitivity+(specificity-1)] showed that a CAIT score  $\leq 24$  was the ideal cut-off point for distinguishing between the groups. The highest sensitivity (80.4%) and specificity (46%) were calculated at this cut-off point (area under the ROC curve of 0.635 for the left ankle and 0.709 for the right ankle, 95% CI).

#### Ceiling and Floor Effects

The CAIT scores showed that there were no floor or ceiling effects for the Persian version of this tool. None of the participants scored the lowest possible score and 11.8% scored the maximum.



**Figure 1:** ROC curve for the Persian version of the CAIT score

## DISCUSSION

The Persian version of CAIT had an appropriate internal consistency and reliability in athletic populations. People with a CAIT score of 24 and lower can be said to have functional ankle instability. Chronic ankle instability usually complicates not only sports performance but also the accomplishment of certain daily life activities (2). An appropriate and useful tool for the detection of chronic ankle instability is therefore necessary for the prevention and management of the adverse effects associated with ankle instability, especially in sports.

A large part of previous studies on functional ankle instability and CAIT have been conducted with the primary goal of translating and cross-culturally adapting the English version of CAIT into multiple languages; however, the characteristics of subjects with recurrent ankle injury have not been homogeneous in these studies. The inconsistency in participant selection criteria across studies limits the comparison of their results. Nevertheless, the psychometric properties of the Persian version of CAIT obtained in the present study were similar to those obtained in previous studies. Similar to the Brazilian-Portuguese (9), Spanish (2) and Japanese (8) versions of CAIT, Hadadi et al. also showed that the Persian version of the CAIT has a high internal consistency (Cronbach's  $\alpha = 0.81$  for the right ankle and  $0.79$  for the left ankle) and reliability (ICC =  $0.95$  for the right ankle and ICC =  $0.91$  for the left ankle) (10). In the present study, the Persian version of CAIT also maintained the good internal consistency evident in other versions. The Persian version of CAIT had a Cronbach's  $\alpha$  of  $0.78$  for the right ankle and  $0.79$  for the left ankle, which fall in the benchmark range of  $0.70-0.95$ . The Persian version of CAIT also demonstrated a substantial reliability (ICC<sub>2,1</sub> =  $0.88$ ) in this study, which is slightly inferior to the values reported for the English version ( $0.96$ ) and other versions. This difference can be explained by noting the interval between the tests in these studies. In the present study, the subjects completed CAIT after three weeks; meanwhile, in the other studies, the interval between the test and retest was one or two weeks.

Original research has established a cut-off score of 27 to indicate FAI. Hiller et al., however, used this cut-off point to distinguish between participants with and without a history of ankle sprain (4). Considering this score, some people who have had a history of ankle sprain but have reported no subjective symptoms of this instability may occasionally be classified as a case of FAI. The

inclusion of these individuals in both groups could affect the scores and lead to the establishment of a higher cut-off value (5).

Several articles have used scores less than 24 to diagnose FAI (12, 14-16). No statistical evidence has been offered in literature to support the selection of a lower cut-off point. Wright et al. recalibrated the cut-off score to 25 for distinguishing between subjects with and without CAI (5). This cut-off point was also examined by Kunugi et al. for the Japanese version of CAIT (8). In the present study, the cut-off score of  $\leq 24$  yielded the highest sensitivity and specificity for discriminating between the two groups.

The sensitivity and specificity obtained in this study had some differences with those obtained in the other studies. The difference in cut-off score between the present study and previous research can be explained by noting the study population; that is, athletes both with and without ankle sprain who may or may not have had giving way were included in the present study. The sensation of giving way was important for discriminating between CAI and non-CAI in both groups. Twenty-nine out of the 37 subjects with a history of ankle sprain in group 1 did not report any sensation of giving way. With the cut-off score of 24, only one subject was marked as FAI; however, if the score was increased to 27, 11 subjects could be diagnosed as FAI. In group 2, 30 subjects with ankle sprain had the sensation of giving way, and ten of these had a CAIT score of 24 and lower. If the cut-off point was increased to 27, 15 subjects could then be diagnosed as FAI. Although the cut-off score of 24 slightly decreases the sensitivity, lower cut-off scores resulted in fewer false positives in the present study. A cut-off score of 24 instead of the original score can improve specificity while maintaining an acceptable sensitivity.

## Limitations

The participants of this study represented a sample of few sports (volleyball, basketball and track and field). Additional participants from a variety of sports and activity levels are necessary in future research to test the Persian version of CAIT with new cutoff score. Another limitation is that mechanical ankle instability was not assessed in this study. Mechanical ankle instability has effect on the unstable feeling with and without functional ankle instability.

## CONCLUSIONS

The Persian version of CAIT has been shown to be a reliable instrument for measuring functional ankle instability in athletic populations. The good

psychometric properties of the Persian version make it a useful tool that can confidently be used for diagnosing functional ankle instability in athletes. The cut-off score of  $\leq 24$  reflects the FAI population more accurately in Iranian athletes.

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#### AUTHORS' CONTRIBUTION

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

#### CONFLICT OF INTEREST

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

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