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Original Research

The Dutch language short Anterior Cruciate Ligament—Return to Sport after Injury scale has good to excellent construct validity, internal consistency, and test-retest reliability when assessing athletes undergoing rehabilitation after ACL injury or ACL reconstruction

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ABSTRACT

Objectives: To examine the validity and reliability of the Dutch language short Anterior Cruciate Ligament—Return to Sport after Injury scale (short ACL-RSI-NL) in recreational athletes undergoing rehabilitation after ACL injury or ACL reconstruction (ACLR).

Methods: The original 12-item version of the ACL-RSI had been translated into Dutch. Short ACL-RSI-NL items were derived from this 12-item Dutch version. Content validity was evaluated by a team consisting of eight ACL experts and eight athletes. A cohort of 115 athletes with ACL injury or after ACLR completed the short ACL-RSI-NL and related questionnaires at various time points during their rehabilitation. Construct validity (hypothesis testing using Spearman correlations), internal consistency (Cronbach's alpha), floor and ceiling effects (percentage of athletes having the lowest or highest score possible), and structural validity (exploratory factor analysis) were evaluated in the entire ACL athlete group. Test-retest reliability (using intra-class correlation, ICC; standard error of measurement, SEM; smallest detectable change, SDC, at both group and individual levels) was investigated in a subgroup of athletes with a stable outcome on psychological readiness within a two-week interval (n = 27).

Results: The short ACL-RSI-NL demonstrated good construct validity (83% of hypotheses confirmed). Internal consistency was excellent (Cronbach's alpha 0.84), and there were no floor and ceiling effects ($\leq 13.9\%$ lowest or highest score). Test-retest reliability was good (ICC 0.89 with 95% CI 0.77–0.95, SEM 6.93, SDC individual level 19.2, SDC group level 3.7). Exploratory factor analysis confirmed the presence of a single underlying factor (accounting for 56.4% of the total variance of the score).

Conclusion: The short ACL-RSI-NL exhibited good to excellent construct validity, internal consistency, and test-retest reliability. An averaged score ranging from 0 to 100 can be used to measure psychological readiness to return to sport. The short ACL-RSI-NL has potential for use in day-to-day practice to assess the psychological readiness of recreational athletes to return to sport after ACL injury or ACLR during their rehabilitation process.

Level of evidence: Level II.

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What are the new findings

- The Dutch language short Anterior Cruciate Ligament—Return to Sport after Injury scale (short ACL-RSI-NL) has good to excellent construct validity, internal consistency, and test-retest reliability in athletes rehabilitating after ACL injury or ACLR.
- The use of an averaged score from 0 to 100 of the short ACL-RSI-NL can measure psychological readiness for return to sport.

1. Introduction

Anterior cruciate ligament (ACL) rupture is a serious injury which may have a significant effect on an athlete's psychological state [1]. During rehabilitation, regardless of whether it is non-operative or post-operative treatment, an athlete's emotions, experiences, and perceptions must be taken into consideration [2]. Orthopaedic surgeons and physical therapists should not take the place of a (sports) psychologist, but being able to detect which athletes have a more negative outlook is important for two major reasons [1].

First, a negative psychological state, especially a higher fear of reinjury and a lower level of self-efficacy, contributes to the failure of athletes returning to sport [3,4]. After ACL reconstruction (ACLR) approximately 50% of all athletes return to the same sport at the same level. One third of the athletes who do not return report fear of reinjury as the main reason for not returning to the same sport at the same level [5,6].

Second, athletes who have greater levels of fear and lower psychological readiness to return to sport are at higher risk of experiencing a second ACL injury when they resume pivoting sports [7,8].

For detecting a possible negative outlook, the Anterior Cruciate Ligament - Return to Sport after Injury scale (ACL-RSI) is a commonly used instrument. This outcome measure is a 12-item patient-reported outcome measure (PROM) addressing athletes' emotions, confidence, and risk appraisal associated with returning to sport after ACLR [9]. It has also been increasingly used to evaluate changes in psychological readiness to return to return to sport during rehabilitation or appraise the efficacy of a psychological intervention during rehabilitation [10]. In a busy clinical environment, where the use of PROMs is embedded in daily care, there is a continuous quest to decrease patient burden by shortening PROMs. Webster et al. in 2018 created a short version of the ACL-RSI, but this ACL-RSI version has not been validated in Dutch [11]. Additionally, the (short) ACL-RSI has only been validated in athletes who have undergone ACLR and are preparing for return to sports. Its validity has never been evaluated in athletes undergoing a non-operative rehabilitation process with the goal of returning to preinjury sport. If clinicians would be able to detect a negative outlook in the early phases of rehabilitation already, this would help athletes battling their negative psychological state early on.

Therefore, the primary aim of this study was to investigate content validity, construct validity, internal consistency, floor and ceiling effects, and test-retest reliability of the Dutch language short ACL-RSI (short ACL-RSI-NL) in athletes at various time points during their rehabilitation after ACL injury or ACLR. Since the original short ACL-RSI has excellent internal consistency and the Dutch translation of the 12-item ACL-RSI has excellent construct validity, internal consistency, and test-retest reliability [11,12], we hypothesised that both validity and reliability of the short ACL-RSI-NL would also be excellent.

The secondary aim was to evaluate structural validity with exploratory factor analysis. Since the original short ACL-RSI has one underlying factor [11], we expected this to be the same for the Dutch language version.

2. Methods

2.1. Participants

Recreational athletes with an ACL injury or after ACLR visiting one of three specialised ACL orthopaedic surgeons at Anna Hospital (Geldrop,

the Netherlands) were asked to participate in this prospective validation study. The athletes could be included when undergoing non-operative or postoperative rehabilitation, as both treatments have the goal of preparing athletes for return to their preinjury sport. Inclusion and exclusion criteria are displayed in Table 1. The first eight eligible athletes were asked to evaluate content validity, the following eligible athletes received two electronic administrations of an online questionnaire package (Online PROMs, Interactive Studios, 's-Hertogenbosch, the Netherlands) with a two-week interval to analyse construct validity, internal consistency, floor and ceiling effects, test-retest reliability, and structural validity.

Additionally, eight ACL experts (four orthopaedic surgeons and four physical therapists) were asked to evaluate content validity. Eligible orthopaedic surgeons performed over 70 ACLRs per year, and eligible physical therapist rehabilitated a minimum of 20 recreational athletes with ACL injuries or after ACLR per year.

All participants gave their informed consent for participation in this validation study.

2.2. Data collection

Eligible athletes were asked to fill in four Dutch language questionnaires: the short ACL-RSI-NL, the Injury Psychological Readiness to Return to Sport (I-PRRS) scale, the International Knee Documentation Committee (IKDC) subjective questionnaire, and the Knee Self-Efficacy Scale (K-SES). Participants who did not respond to the first administration, received automatic reminders after one and two days. Only athletes who completed the first administration were sent the second administration. Athletes, who did not respond to the second administration, also received reminders after one and two days.

The original 12-item version of the ACL-RSI had been translated into Dutch [12]. Short ACL-RSI-NL items were derived from this 12-item Dutch version [11,12]. I-PRRS, IKDC subjective questionnaire, and K-SES had all been validated in Dutch before [15–17]. I-PRRS consists of six 11-point items that assess confidence in returning to sport. Total score varies between 0 and 60, with a score above 50 indicating the athlete is ready to return to sports. The Dutch I-PRRS has a Cronbach's alpha of 0.85, an intra-class correlation (ICC) of 0.74, and a standard error of measurement (SEM) of 2.02 [15]. The IKDC subjective questionnaire consists of 11 items, and the total score ranges between 0 and 100. A score of 100 represents the absence of knee symptoms and no restrictions in daily life and during sport. The Dutch version of the IKDC subjective questionnaire has a Cronbach's alpha of 0.92 in a mixed knee injury group (osteoarthritis, meniscal injury, and ligament injuries), and an ICC of 0.96 [16]. The K-SES consists of 22 items with an 11-point scale that assess confidence in the present and future functioning of the knee, and its total score varies between 0 and 10, with a higher score representing higher self-efficacy. The K-SES could be separated in a 0–10 score for present functioning (item 1–18) and a 0–10 score for future functioning (item 19–22) [18]. The Dutch K-SES has a high internal consistency (Cronbach's alpha 0.95) for both patients after ACL injury and those with

Table 1

Inclusion and exclusion criteria of eligible recreational athletes with ACL injury or ACLR.

| Inclusion criteria | Exclusion criteria |
|---|--|
| 16 years old or above | History of contralateral ACL injury, treated both non-operatively or operatively |
| Undergoing rehabilitation according to ACL practice guidelines with a physical therapist ³ | Ipsilateral ACLR |
| Participating in pivoting sports* on a weekly basis before ACL injury | Inability to speak and read Dutch |

ACLR, anterior cruciate ligament reconstruction

* Pivoting sports are sports with frequent lateral and pivoting movements (eg, soccer, handball, basketball, alpine skiing, racket sports).¹⁴

ACLR. It also has excellent test-retest reliability with an ICC of 0.92 and SEM of 0.46 [17].

The medical ethics committee of the Máxima Medisch Centrum Eindhoven (the Netherlands) deemed that our study did not fall within the remit of the Medical Research Involving Human Subjects Act (N20.024).

2.3. Analysis of measurement properties

The Consensus-based Standards for the selection of health Measurement INstruments (COSMIN) study design checklist was used as a guide to evaluate the measurement properties of the short ACL-RSI-NL, including content validity, construct validity, internal consistency, floor and ceiling effects, test-retest reliability, and structural validity [19].

2.3.1. Content validity

A team consisting of eight ACL experts (four orthopaedic surgeons and four physical therapists) and eight ACL athletes (six after ACLR and two following non-operative treatment) was created to evaluate content validity.

Four out of the six original short ACL-RSI items (2, 4, 5, and 6) already drew attention to the knee by incorporating “your knee” into these items. However, when the original short ACL-RSI was validated, athletes not returning to their preinjury sport level because of non-knee-related medical reasons were excluded [11]. Reality shows one third to half of all athletes after ACLR who do not return to their preinjury sport level have non-knee-related reasons (e.g. no more time for team sports and degradation of their own team) [4,6]. Additionally, when administering the paper version of the short ACL-RSI in daily practice, the first author (NvM) noticed that many patients asked if items 1 and 3 were specifically about their knee or if they had to provide more in general responses. Therefore, we decided to explore if ACL experts and ACL athletes agreed to incorporate a reference to the athlete's knee into item 1 and 3 as well (item 1: “Are you confident that you can perform at your previous level of sport participation?”; item 3: “Are you nervous about playing your sport?”). To investigate this, we used two different versions of the short ACL-RSI-NL: version 1, which was the same as the original short ACL-RSI, and an adjusted version 2 that incorporated a reference to the athlete's knee into item 1 and 3.

The team consisting of ACL experts and ACL athletes was asked to rate the relevance, comprehensiveness, and comprehensibility of each item. Each item in both versions of the short ACL-RSI-NL was rated on an importance scale of 1–3 (1 = unimportant, 2 = somewhat important, 3 = very important). These rating data were used to calculate mean importance scores for each item [11]. Besides rating individual items, all experts and athletes were asked to state which version of the short ACL-RSI-NL they preferred. When at least five experts and five athletes had the same preference and this was also visualised in higher mean importance scores for items 1 and 3, this preferred version was used for the further validation process.

2.3.2. Construct validity

To determine construct validity, six a-priori hypotheses were formulated about expected relationships with other outcome measures of good quality. Spearman correlations were calculated for all hypotheses. Construct validity was considered good when >75% of these hypotheses are confirmed [19].

The following hypotheses were formulated:

1. A high correlation ($r > 0.60$) between the short ACL-RSI-NL confidence in performance domain and K-SES future subscale.
2. A moderate correlation ($r = 0.30\text{--}0.60$) between the short ACL-RSI-NL risk appraisal domain and K-SES future subscale.
3. A moderate correlation ($r = 0.30\text{--}0.60$) between the short ACL-RSI-NL and K-SES present subscale.

4. A high correlation ($r > 0.60$) between the short ACL-RSI-NL confidence in performance domain and I-PRRS.
5. A moderate correlation ($r = 0.30\text{--}0.60$) between the short ACL-RSI-NL emotions domain and I-PRRS.
6. A moderate correlation ($r = 0.30\text{--}0.60$) between the short ACL-RSI-NL and IKDC subjective questionnaire.

2.3.3. Internal consistency

Internal consistency of the short ACL-RSI-NL was assessed with Cronbach's alpha using data from the first administration. Cronbach's alpha should be between 0.70 and 0.90 [20].

2.3.4. Floor and ceiling effects

The short ACL-RSI-NL as a whole, the three domains, and all items separately were examined for floor and ceiling effects. A floor or ceiling effect is present when more than 15% of the athletes achieve the lowest or highest score possible, respectively [21].

2.3.5. Test-retest reliability

Test-retest reliability and SEM were determined in a group of athletes who achieved a stable outcome on the I-PRRS and completed the short ACL-RSI-NL twice, with a two-week interval. A stable outcome was defined as an I-PRRS change of less than six, considering that the smallest detectable change (SDC) is 5.58 [15].

To determine test-retest reliability, the ICC (two way random effects, absolute agreement, single rater) with corresponding 95% confidence interval (CI) was calculated. An ICC value of >0.75 was considered good [19]. The SEM was calculated as the square root of the within-subject variance. Subsequently, the SEM was used to calculate the SDC at individual level ($SDC_{ind} = 1.96 * \sqrt{2} * SEM$) and at group level ($SDC_{group} = SDC_{ind}/\sqrt{n}$).

2.3.6. Structural validity

The original short ACL-RSI describes three separate domains with one underlying factor and an averaged score from 0 to 100, with 100 representing the highest level of psychological readiness to return to sport. The three domains are emotions (item 3, 5, and 6), confidence in performance (item 1 and 4) and risk appraisal (item 2) [11]. Exploratory factor analysis with Varimax rotation was used to uncover the underlying theoretical constructs of the short ACL-RSI-NL and to determine if there is also a single underlying construct in the Dutch translation.

All analyses were performed using IBM Statistical Package for the Social Sciences, version 26.0 (SPSS Inc., Armonk, NY).

3. Results

The flow of recreational athletes with ACL injuries or after ACLR, as well as which data were used for analysing the measurement properties of interest, is visualised in Fig. 1. In total, 115 ACL athletes completed the first electronic administration. Among them, twenty-two athletes (19.1%) underwent non-operative treatment, while 93 athletes (80.9%) were undergoing postoperative rehabilitation. Athlete characteristics are described in Table 2. The scores from the first administration of the short ACL-RSI-NL, the I-PRRS, the IKDC subjective questionnaire, and the K-SES present and future subscales are displayed in Table 3.

Fifty-seven ACL athletes completed the second electronic administration. Among these athletes, only 27 had a stable outcome on the I-PRRS and were included in the analysis of test-retest reliability. Nineteen athletes showed an improvement of six points or more between both administrations, while eleven had a score that decreased six points or more. Therefore, according to the COSMIN checklist, these 30 athletes were excluded in the analysis of test-retest reliability. These 30 excluded athletes did not differ from the 27 included athletes (Table 4).

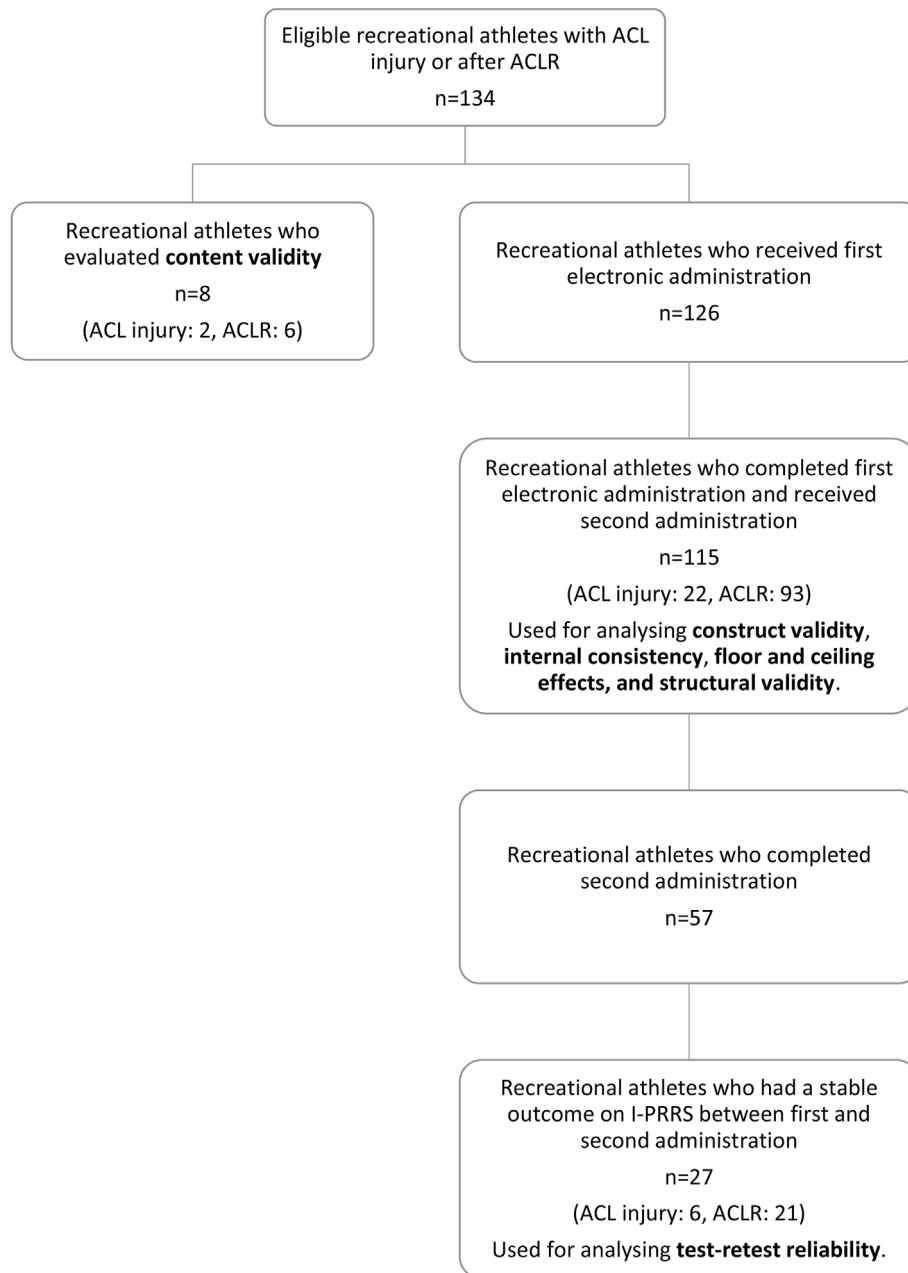


Fig. 1. Flowchart of recreational athletes with ACL injury or after ACLR. ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction.

Table 2

Characteristics of 115 ACL athletes who filled in the first electronic administration.

| | |
|---|-------------------------------|
| Sex, n (%) female | 50 (43.5) |
| Age in years, mean \pm sd (range) | 26.3 \pm 7.6 (16.0–46.0) |
| Height in cm, mean \pm sd (range) | 176.5 \pm 9.1 (158.0–197.0) |
| Weight in kg, mean \pm sd (range) | 75.3 \pm 13.8 (52.0–115.0) |
| Injured side, n (%) right | 57 (48.7) |
| Operative treatment, n (%) | 93 (80.9) |
| Time after surgery in months, mean \pm sd (range) | 7.4 \pm 3.9 (0.8–16.0) |
| Non-operative or preoperative treatment, n (%) | 22 (19.1) |
| Time after injury in months, mean \pm sd (range) | 14.1 \pm 20.6 (1.1–89.9) |

3.1. Content validity

Six ACL experts and seven ACL athletes preferred version 2 of the short ACL-RSI-NL, incorporating a reference to the athlete's knee into item 1 and 3. Importance scores for item 1 and 3 of version 1 were also lower (2.69

and 2.56) than the importance scores for item 1 and 3 of version 2 (2.75 and 2.69). Therefore, we decided to incorporate a reference to the athlete's knee into item 1 and 3 of the short ACL-RSI-NL. Although two experts and two athletes stated too much similarity between item 2 and 6, intercorrelation between these items was low (Spearman's $r = 0.45$), and consequently, all items were kept in the short ACL-RSI-NL.

3.2. Construct validity

Table 5 shows all Spearman correlations for the short ACL-RSI-NL. Construct validity of the short ACL-RSI-NL is considered good with five out of six (83%) a-priori hypotheses confirmed.

3.3. Internal consistency

The short ACL-RSI-NL had an excellent internal consistency, with Cronbach's alpha being 0.84.

Table 3
Questionnaire scores from 115 ACL athletes who filled in the first electronic administration.

| | Mean (sd) | Minimum | Maximum | n ₀ (%) | n ₁₀ (%) / n ₁₀₀ (%) |
|---|-------------|---------|---------|--------------------|--|
| Short ACL-RSI-NL item 1 score | 63.9 (27.8) | 0 | 100 | 9 (7.8) | 12 (10.4) |
| Short ACL-RSI-NL item 2 score | 58.3 (22.8) | 0 | 100 | 5 (4.3) | 5 (4.3) |
| Short ACL-RSI-NL item 3 score | 55.6 (26.6) | 0 | 100 | 4 (3.5) | 9 (7.8) |
| Short ACL-RSI-NL item 4 score | 53.4 (26.9) | 0 | 100 | 8 (7.0) | 6 (5.2) |
| Short ACL-RSI-NL item 5 score | 42.2 (29.9) | 0 | 100 | 16 (13.9) | 8 (7.0) |
| Short ACL-RSI-NL item 6 score | 49.3 (26.3) | 0 | 100 | 5 (4.3) | 5 (3.5) |
| Short ACL-RSI-NL total score | 53.8 (19.8) | 0 | 100 | 2 (1.7) | 1 (0.9) |
| Short ACL-RSI-NL emotions domain (item 3, 5 and 6) | 49.0 (22.6) | 0 | 100 | 2 (1.7) | 3 (2.6) |
| Short ACL-RSI-NL confidence in performance domain (item 1 and 4) | 58.7 (24.0) | 0 | 100 | 3 (2.6) | 3 (2.6) |
| Short ACL-RSI-NL risk appraisal domain (item 2) | 58.3 (22.8) | 0 | 100 | 5 (4.3) | 5 (4.3) |
| I-PRRS | 70.5 (20.0) | 6.7 | 100.0 | 0 (0.0) | 1 (0.9) |
| IKDC subjective questionnaire | 61.4 (11.9) | 32.2 | 86.2 | 0 (0.0) | 0 (0.0) |
| K-SES present subscale | 7.2 (2.2) | 1.9 | 10.0 | 0 (0.0) | 5 (4.3) |
| K-SES future subscale | 6.2 (2.1) | 0 | 9.8 | 1 (0.9) | 0 (0.0) |

Table 4
Comparison between athletes who were included for test-retest analysis (stable outcome on the I-PRRS) and athletes who were excluded (no stable outcome).

| | Stable outcome (n = 27) | No stable outcome (n = 30) | p-value |
|---------------------------------|----------------------------|-------------------------------|---------|
| Sex, n (%) female | 15 (55.6) | 12 (40.0) | 0.240 |
| Age in years, mean ± sd | 24.0 ± 6.4 | 28.0 ± 9.1 | 0.058 |
| Height in m, mean ± sd | 1.75 ± 0.10 | 1.78 ± 0.09 | 0.361 |
| Weight in kg, mean ± sd | 74.7 ± 13.5 | 75.8 ± 14.3 | 0.769 |
| Treatment, n (%) operative | 21 (77.8) | 26 (86.7) | 0.378 |
| Baseline short ACL-RSI-NL score | 59.8 ± 20.9 | 49.1 ± 20.4 | 0.054 |

Table 5
Spearman correlations for short ACL-RSI-NL per hypothesis.

| | Spearman correlation | Hypothesis confirmed? |
|--------------|----------------------|-----------------------|
| Hypothesis 1 | 0.70 | Yes |
| Hypothesis 2 | 0.52 | Yes |
| Hypothesis 3 | 0.34 | Yes |
| Hypothesis 4 | 0.63 | Yes |
| Hypothesis 5 | 0.45 | Yes |
| Hypothesis 6 | 0.27 | No |

3.4. Floor and ceiling effects

In this population, the proportion of athletes scoring the lowest (zero) or highest (100) score on the short ACL-RSI-NL or one of the three domains did not exceed 4.3% (Table 3), and for all items separately did not exceed 13.9%, which demonstrates the absence of floor and ceiling effects.

3.5. Test-retest reliability

The short ACL-RSI-NL had a good test-retest reliability with single measure ICC being 0.89 (95% CI 0.77–0.95). The SEM was 6.9 and the SDC_{ind} was 19.2 points. The SDC_{group} (n = 27) was 3.7 points.

3.6. Structural validity

Exploratory factor analysis of the short ACL-RSI-NL confirmed one underlying factor which accounted for 56.4% of the total variance of the score.

4. Discussion

The most important finding of the present study is that the short ACL-RSI-NL demonstrates good to excellent construct validity, internal

consistency, and test-retest reliability, and the absence of floor and ceiling effects, in recreational athletes undergoing rehabilitation after ACL injury or ACLR. Factor analysis confirmed the presence of a single underlying factor (e.g. psychological readiness to return to sport), which justifies the use of an averaged score from 0 to 100.

One of our hypotheses (hypothesis 6) was not confirmed when determining construct validity. The Spearman correlation between the short ACL-RSI-NL and IKDC subjective questionnaire was low (r = 0.27), indicating a weak correlation between psychological readiness and physical functioning. This finding is consistent with the results of the translation of the ACL-RSI to Norwegian by Faleide et al., who found only a small correlation between physical performance on strength and hop tests and the ACL-RSI score [22]. It can be concluded that athletes during rehabilitation may have poor physical functioning while exhibiting high levels of psychological readiness, and vice versa. This emphasises the importance of measuring both physical performance and psychological readiness during rehabilitation after ACL injury or ACLR.

Internal consistency of the short ACL-RSI-NL is higher than that in the Arabic and Brazilian Portuguese translation, with Cronbach's alpha being 0.84 for the Dutch version compared to 0.73 and 0.78 for both other translations, respectively [23,24]. Although there is some variation in internal consistency of all translations, all Cronbach's alphas are within the recommended range of 0.70–0.90 [20]. Cronbach's alpha of the short ACL-RSI-NL was also better than the Cronbach's alpha of 0.92 of the original ACL-RSI and the Cronbach's alpha of 0.94 of the Dutch 12-item version [11,12] because a value of above 0.90 could indicate item redundancy, indicating the PROM has too many items and there is a need for a shorter version [20]. Test-retest reliability is comparable to both other translated versions and the Dutch 12-item version, which have an ICC of 0.87, 0.85, and 0.93, respectively, and a SEM of 7.2, 5.0, and 5.5, respectively [18,23,24]. The Arabic version had an SDC_{ind} of 20.8 and an SDC_{group} of 3.4 (n = 34), which is similar to the SDC_{ind} of 19.2 and the SDC_{group} of 3.7 of the short ACL-RSI-NL [24]. An SDC_{ind} of 15–25% of the total score is also comparable to other knee-related questionnaires or other language (short) ACL-RSI questionnaires [10, 12,22,24–27].

4.1. Clinical applicability of the short ACL-RSI-NL and future recommendations

As the measurement properties of the short ACL-RSI-NL are good to excellent, this PROM could be helpful in evaluating psychological readiness over time and assessing whether recreational athletes after ACL injury or ACLR are ready to return to sports. When evaluating psychological readiness over time, it is important to know that different psychological patterns for athletes after injury have been defined. Morrey

et al. have identified that athletes' emotions fluctuate in a 'U-shaped' pattern during rehabilitation, starting with negative emotions as a result of injury or surgery, progressing to a better psychological state during the middle part of rehabilitation, and encountering more elevated mood disturbances again towards clearance to return to sport [28]. In contrast, Quinn and Fallon found that athletes' emotions either steadily decrease or fluctuate up and down over time [29]. This suggests that not all athletes experience the same emotional response to rehabilitation, and there is considerable variation in psychological readiness among athletes at different time points during rehabilitation.

When assessing whether an athlete is psychologically ready to return to sport, a cut-off value could be a helpful tool for clinicians. The original short ACL-RSI has a cut-off score of 60 points (with a sensitivity of 50% and specificity of 84%) for returning to sports at 12 months post-ACLR when completing the questionnaire at six months postoperatively [11]. Approximately the same cut-off score of 62 points was found for the English 12-item version, with a sensitivity of 57% and specificity of 81% [11]. In a cohort of patients aged 20 years or younger, completing the English 12-item ACL-RSI at 12 months postoperatively, a cut-off score of 76.7 points (with 90% sensitivity and 47% specificity) was found for predicting second ACL injury [8].

Regarding the interpretation of the total short ACL-RSI-NL score, it is important to keep in mind that the SDC_{ind} is 19.2 points. This means that a retest score that changes less than 19.2 points could be due to a measurement error. A true change in psychological readiness for an individual patient would require a score of 19.2 points or more. On the other hand, the SDC_{group} was 3.7 points, which is significantly smaller. However, this SDC is only useful when analysing groups of athletes, such as for research purposes.

4.2. Limitations

Only 27 athletes were available for calculating the test-retest reliability, while the COSMIN study design checklist advises using a sample of at least 50 patients for this purpose. However, since all athletes were measured at different time points from injury or surgery during their rehabilitation process, variation in improvement or deterioration of psychological readiness was expected, and could explain the limited number of patients.

Additionally, to monitor athletes during rehabilitation through repeated measurements, adequate responsiveness of the short ACL-RSI-NL is required which we have not evaluated in this study. Future studies should be performed to assess responsiveness, as well as minimal clinical important differences of the outcome.

5. Conclusion

The short ACL-RSI-NL demonstrates good to excellent construct validity, internal consistency, and test-retest reliability. The use of an averaged score ranging from 0 to 100 demonstrated proper measurement of psychological readiness to return to sport. Based on these results, the short ACL-RSI-NL has potential for use in day-to-day practice to assess the psychological readiness of recreational athletes to return to sport after ACL injury or ACLR during their rehabilitation process.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical approval

The medical ethics committee of the Máxima Medisch Centrum Eindhoven (the Netherlands) deemed that our study did not fall within the remit of the Medical Research Involving Human Subjects Act (N20.024).

Informed consent

All participants gave their informed consent for participation in this validation study.

Authors contributions

Research design: NvM-IS-RA-KW-RB, data acquisition: NvM-RB, analysis: NvM-IS, drafting paper: NvM-IS-RA, revising paper: NvM-IS-RA-KW-RB.

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Appendix. short ACL-RSI-NL

Instructies: Beantwoord de volgende vragen met betrekking tot uw hoofdsport die u voorafgaand aan uw blessure beoefende. Kruis bij elke vraag een vakje aan tussen de twee beschrijvingen om aan te geven hoe u zich op dit moment voelt ten opzichte van de twee uitersten.

1. Bent u er zeker van dat u, ondanks uw knieblessure, weer op uw oude niveau uw sport kunt beoefenen?

Helemaal niet zeker Helemaal zeker

0 1 2 3 4 5 6 7 8 9 10

2. Denkt u dat u waarschijnlijk uw knie opnieuw zal blessuren bij het beoefenen van uw sport?

Heel erg waarschijnlijk Helemaal niet waarschijnlijk

0 1 2 3 4 5 6 7 8 9 10

3. Bent u zenuwachtig over het beoefenen van uw sport vanwege uw knie?

Heel erg zenuwachtig Helemaal niet zenuwachtig

0 1 2 3 4 5 6 7 8 9 10

4. Weet u zeker dat u uw sport kan beoefenen zonder bezorgd te zijn over uw knie?

Helemaal niet zeker Helemaal zeker

0 1 2 3 4 5 6 7 8 9 10

5. Vindt u het frustrerend rekening te moeten houden met uw knie in uw sport?

Heel erg frustrerend Helemaal niet frustrerend

0 1 2 3 4 5 6 7 8 9 10

6. Bent u bang opnieuw geblesseerd te raken aan uw knie door het beoefenen van uw sport?

Heel erg bang Helemaal niet bang

0 1 2 3 4 5 6 7 8 9 10

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