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Original Research

A comparison of anterior cruciate ligament - Return to sports after injury (ACL-RSI) scores of male athletes nine-months Post-ACL reconstruction with matched uninjured controls

B. Phelan [a, *], E. King [b], C. Richter [b], K. Webster [c], E. Falvey [a, b]

[a] College of Medicine and Health, University College Cork, Cork, Ireland
[b] Sports Medicine Department, Sports Surgery Clinic, Santry Demesne, Dublin, Ireland
[c] School of Allied Health, La Trobe University, Melbourne, Australia

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ABSTRACT

Objectives: To report ACL-RSI scores in healthy athletes with no history of ACL injury. To measure ACL-RSI scores at nine-months post-ACL reconstruction and to assess the difference between healthy athlete and patient responses.
Design: Cross-sectional study.
Setting: Private sports clinic.
Participants: 499 ACL reconstruction athletes completed the scale as they returned for their nine-month post-operative review appointment. A matched control group of 103 healthy athletes were selected for comparison.
Main outcome measures: ACL-RSI for participants with controls completing a study-specific modified scale.
Results: The median response to the ACL-RSI for the control group was higher (80.0) (Interquartile Range (IRQ) 66.7–88.3) than that of the ACL reconstruction group (74.17) (IRQ 59.2–86.0), however the effect size was small (0.1).
Conclusion: This study reports normative values for uninjured athletes using the ACL-RSI questionnaire giving a benchmark for recovery after ACLR but also reflecting awareness of injury risk in uninjured athletes. ACL-RSI scores nine-months post-operatively had not yet returned to levels seen in matched uninjured controls.

1. Introduction

Injury to the anterior cruciate ligament (ACL) is a relatively common occurrence in sporting populations. Rates of ACL injury among athletes are reported as 38.9 (95% CI 30.7–49.3) per 100,000 person-years depending on sport played, level of participation and sex (Johnsen et al., 2016; Majewski M Susanne H, 2006; Müller, Krüger-Franke, Schmidt, & Rosemeyer, 2015; Tripp, Stanish, Ebel-Lam, Brewer, & Birchard, 2007).

ACL rupture has been shown to be one of the most debilitating orthopaedic injuries suffered by athletes (Mai et al., 2016), in terms of performance, sporting participation, career length and lifetime osteoarthritis risk (Arundale, Silvers-Granelli, & Snyder-Mackler, 2018; Spahn et al., 2016). Unfortunately, ACL reconstruction (ACLR) does not guarantee a return to premorbid activity levels. A large systematic review reported that 55% of athletes return to competitive sport following ACLR (Ardern, Taylor, Feller, & Webster, 2014). Low rates of return are reported despite studies demonstrating the recovery of subjective scores of knee-function following rehabilitation (Ardern, Taylor, Feller, Whitehead, & Webster, 2015; Lefevre et al., 2017).

ACL injury may have a substantial psychological impact on the athlete (Ardern, Taylor, Feller, Whitehead, & Webster, 2013), with implications for poor rates of return to sport after ACLR (Flanigan, Everhart, Pedroza, Smith, & Kaeding, 2013; Lee, Karim, & Chang, 2008; te Wierike, van der Sluis, van den Akker-Scheek, Elferink-Gemser, & Visscher, 2013). Fear of re-injury is noted among patients following ACLR (Flanigan et al., 2013) and is a commonly cited

* Corresponding author. Cappagh, Dungarvan, Co. Waterford, Ireland.
E-mail address: 114120224@umail.ucc.ie (B. Phelan).

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reason for non-return to sport (Flanigan et al., 2013; Flanigan, Everhart, & Glassman, 2015; Lee et al., 2008; Tripp et al., 2007).

The Anterior Cruciate Ligament–Return to Sports After Injury Scale (ACL-RSI) is a specific 12-item questionnaire which was developed to examine athletes' emotions, confidence and risk appraisal when returning to sport after ACLR (K E Webster, Feller, & Lambros, 2008). The scale, developed by Webster and colleagues in 2008 (K E Webster et al., 2008), has since been translated to a number of languages allowing for inter-country comparisons. No significant floor or ceiling effects have been found in the scale by any of these translated studies (Bohu, Klouche, Lefevre, Webster, & Herman, 2015; Chen et al., 2017; Harput et al., 2016; Kvist et al., 2013; Silva, Mendes, Lima, & Almeida, 2017; Slagers, Reininga, & van den Akker-Scheek, 2016). The questionnaire has good internal consistency and has demonstrated construct validity and test–retest reliability (Ardern, Österberg, et al., 2014; Kvist et al., 2013; K E; Webster et al., 2008).

The scale has been consistently found to be associated with a return to sport (Ardern et al., 2013, 2016; Ardern, Österberg, et al., 2014; Bohu et al., 2015; Harput et al., 2016; Langford, Webster, & Feller, 2009; Müller et al., 2015). It has shown that those athletes who returned to full competition following ACLR had significantly higher ACL-RSI scores than those who failed to return (Ardern, Österberg, et al., 2014; Bohu et al., 2015; Harput et al., 2016; Kvist et al., 2013; Langford et al., 2009; K E; Webster et al., 2008). A shortened version of the ACL-RSI was recently published and has been shown to be equivalent to the full version in discriminating between and predicting return to sport outcomes (Kate E. Webster & Feller, 2018). Low scores on the ACL-RSI (short version) among younger patients are associated with a higher risk of a second ACL injury (McPherson, Feller, Hewett, & Webster, 2019). Previous research has identified differences in both injury rates and ACL-RSI scores between genders (Harmon & Ireland, 2000; Milewski et al., 2016). There is no data regarding normative scores for ACL-RSI in uninjured male athletes or how these scores compare to those who have undergone ACLR.

The aim of this study was to report ACL-RSI scores for healthy male athletes and to compare them with ACL-RSI scores of male athletes nine-months post-reconstruction. Our hypothesis was that healthy athletes scores would reflect an inherent baseline awareness about ACL injury (i.e. would not achieve a maximum score of 100). In addition, the healthy cohort would demonstrate higher ACL-RSI scores than those nine-months after ACR.

2. Methods

2.1. Study design and setting

Local sports teams were approached to recruit age and sex-matched controls during October and November 2017 for participation in this cross-sectional study. Inclusion criteria for the control group were: adult males, active participants in Level 1 amateur field sports, aged 18–35 years. Teams were approached to provide necessary number of players from each sport to correspond to the percentages of athletes involved in the ACLR group. Sports included were Gaelic football (40% of athletes), football (25%), rugby (20%), and hurling (15%). Exclusion criteria for the control group were previous ACL injury or knee surgery including meniscal or ligamentous repair, professional athletes and current knee pain. Field sports were defined as high demand sports involving jumping, landing and multidirectional movement played on a field. The ACL-RSI questionnaire was modified for the control group in regards to questions relating directly to ACLR following ACL injury (Appendix B). The alterations involved were to the wording of four questions to remove any reference to the surgery or re-injury. Alterations to the questions 1, 2, 7 and 10 are illustrated in Fig. 1 below.

ACLR subjects were recruited after undergoing surgery between January 2014 and October 2017 in a private sports clinic for this cross-sectional study. The ACL-RSI data for the ACL group (Appendix A) was captured on an iPad at their nine-month review prior to a physical testing battery involving strength, jump and change of direction testing. The standardised post-operative rehabilitation pathway undertaken has been described previously and includes frequent orthopaedic and physical therapy reviews. Following a 2-week period of weight bearing as tolerated on crutches post-operatively, patients followed a progressive strengthening and neuromuscular control program before advancing to linear running and change of direction training (King et al., 2019). The inclusion criteria for the ACL group were: adults aged 18–35 years, primary ACLR, amateur athletes playing Level 1 field sports, whose pre-operative intention was to return to the same level of sporting participation. Exclusion criteria included: second or subsequent ACLR, reconstruction of other knee ligaments at the time of surgery and female athletes. Informed consent was attained from both groups prior to participation. Demographic information for both groups is provided below in Table 1.

2.2. Ethical approval

Ethical approval was obtained for this study.

2.3. Data analysis

The data was analysed using MATLAB R2015a (MathWorks). A-priori sample size calculation was not performed but study size was based on the maximum number of consecutive eligible respondents to the ACL-RSI ($n = 499$). The number of matched controls was 103 and post hoc power calculation resulted in a power of $\beta = 0.937$ confirming the appropriateness of the sample size. Before examining differences between the samples, a 2-sample Kolmogorov-Smirnov test was used to determine if the data was normally distributed. As the data was not normally distributed ($p = 0.0493$), a Wilcoxon Rank Sum test was performed to examine differences between the two groups. The alpha level was set as $\alpha = 0.05$. Furthermore, the magnitude of the non-parametric differences between groups was calculated using effect sizes by dividing the test statistic by the square root of the number of observations (Pallant, 2011) which were classified as small - $\leq$0.1, medium - $\leq$0.3 and large - $\leq$0.5(Cohen, 1988).

Q1. Are you confident that you can perform at your previous level of sporting participation?
Q1. (Revised) Are you confident that you can perform at your usual level of sporting participation?

Q2. Do you think you are likely to re-injure your knee by participating in your sport?
Q2. (Revised) Do you think you are likely to injure your knee(s) while playing sport?

Q7. Are you fearful of re-injuring your knee by playing your sport?
Q7. (Revised) Are you fearful of injuring your knee(s) while playing your sport?

Q10. Do thoughts of having to go through surgery and rehabilitation again prevent you from playing your sport?
Q10. (Revised) Do thoughts of injuring your knee and having to go through subsequent rehabilitation prevent you from playing your sport?

Fig. 1. Modifications made to appropriate questions.

Table 1
Demographic data of participants and controls.

	Control Group	ACL-Injured Group
Mean Age	24.3 years	24.6 years
Level of sport	1	1
Sport Played		
Gaelic Football	38%	40%
Soccer	26%	25%
Rugby	18%	20%
Hurling	18%	15%
Return to Play at 9 months	N/A	249 (49%)

3. Results

The median ACL-RSI score was 80.0 (IRQ 66.7–88.3) for the control group compared to 74.17 (IRQ 59.2–86.0) for the ACLR group. There was a significant difference between groups ($p = 0.01$) but with a small effect size (0.1). The data is illustrated in Fig. 2.

4. Discussion

This study is the first to report normative values for ACL-RSI in previously un-injured athletes and compares scores with athletes nine-months after ACLR. The results give a baseline score for uninjured athletes and demonstrate a small magnitude difference between groups.

The normative scores of matched healthy subjects provide a baseline of their risk appraisal, emotion, and confidence as measured by the ACL-RSI. The scores for the control group were submaximal, perhaps indicating an inherent baseline concern or awareness regarding ACL injury is prevalent among healthy, previously uninjured subjects. It could be assumed that healthy athletes without ACL injury or any current knee pain would be confident in the health and function of their knees and therefore have near perfect scores in the ACL-RSI. The participants in this study are Level 1 field sport athletes across a variety of sports in which knee injuries and more specifically ACL injuries are common (Murphy, O'Malley, Gissane, & Blake, 2012; Nessler, Denney, & Sampley, 2017; Roe M Blake C, 2016). It is possible that the relative prevalence and serious impact of ACL injury experienced by fellow athletes, role models and teammates influences the confidence in knee function of these uninjured athletes. Athletes may aware of the potential for injury despite being currently uninjured themselves and therefore a perfect score on the ACL-RSI may not be achievable.

It was our hypothesis that subjects post-ACLR would have lower scores on the ACL-RSI. The results support our hypothesis and suggests that while their scores at nine-months following ACLR were recovering they had not risen to levels seen in matched healthy subjects at that time point. However the differences between groups, although significant were only small in effect size with large overlap of IRQ and the minimal clinically important difference for the ACL-RSI is also not known. It has previously been shown that ACL-RSI scores increase over time post-reconstruction but it may be that the normalisation of scores only occurs after a prolonged successful exposure back to sport (Sadeqi et al., 2018). This may not yet have taken place at nine-months and may account for the difference between groups in this study given the time proximity to initial injury and surgery. ACL-RSI scores among participants in this study were slightly higher than previously reported (Ardern et al., 2015, 2013; Harput et al., 2016; Kvist et al., 2013; Langford et al., 2009; Lefevre et al., 2017; Müller et al., 2015; Slagers et al., 2016). An inclusion criteria for this study was that participants were intending to return to their preinjury level of sporting participation which is not always the case in previous studies reporting ACL-RSI scores and this may be reflected in a higher intrinsic motivation prior to surgery (Ardern, Österberg, et al., 2014; Ardern et al., 2013; Kvist et al., 2013; Lefevre et al., 2017). The participants in this study also underwent a physical review pathway at 3, 6 and 9 months involving strength and 3D biomechanical analysis of jumping and change of direction tests. Involvement in this pathway may have influenced their self-efficacy and confidence in their physical recovery to make a successful return.

While high ACL-RSI scores are associated with a successful return to sport (Ardern et al., 2013, 2016; Ardern, Österberg, et al., 2014; Bohu et al., 2015; Harput et al., 2016; Langford et al., 2009; Müller et al., 2015), clinicians must be aware that athletes who

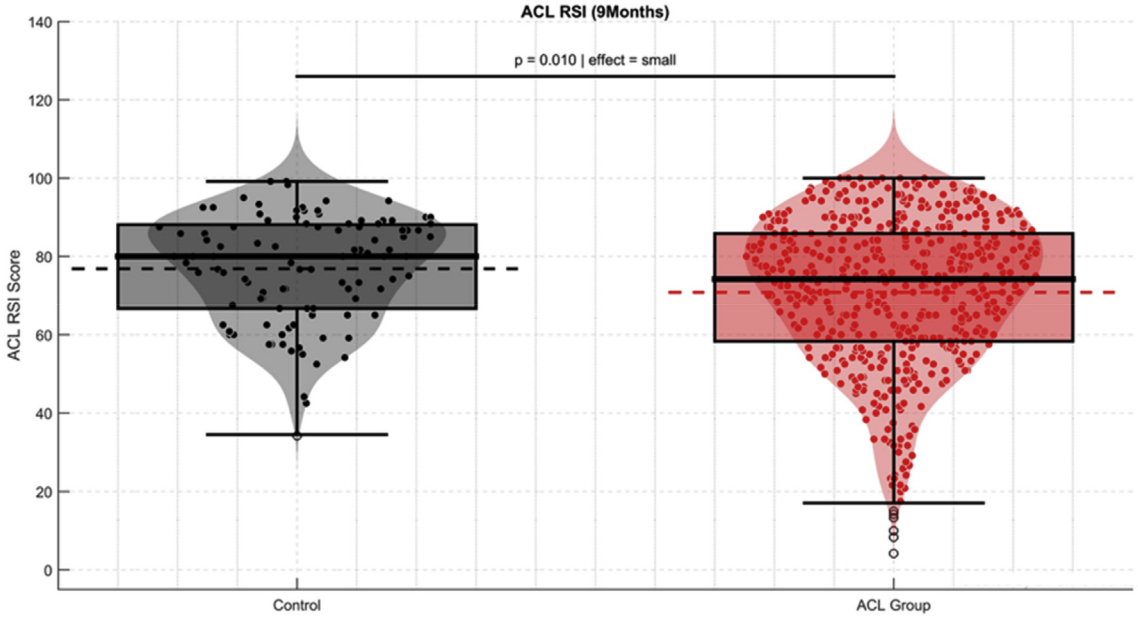

Fig. 2. Distribution of ACL-RSI scores among control and ACL groups at 9 months.

score highly may not have physically recovered enough to perform a safe return to sport. Lentz and colleagues describe this phenomenon where athletes with low fear and high self-efficacy return to high risk activities before being physically prepared, increasing the risk of injury after return (Lentz, Paterno, & Riboh, 2018).

Establishing normative scores for healthy male subjects may provide a comparison for athletes who underwent ACLR and identify who may need more targeted intervention prior to returning to play. Behavioural modification strategies, goal setting and cognitive behavioural therapy have all been proposed as methods to address some of the non-physical factors restricting athletes post-operatively (Ardern et al., 2016; Flanigan et al., 2015). In combination with a physical therapy programme, these interventions may facilitate better ACL-RSI scores by the nine-month mark post-surgery. Control data from our study may act as a benchmark for future intervention studies to improve self-perceived readiness to return to play. Similarly in clinical practice, normal ACL-RSI scores may be used as a target or perhaps as a minimum value for athletes to achieve prior to being permitted to return to play. Addressing deficiencies in risk appraisal, emotions and confidence might then aid in a successful return to premorbid sporting participation.

Information bias is a potential limitation when interpreting the results of this study due to the modification to the ACL-RSI completed by the control group. Efforts were made to ensure the modifications were as slight as possible and just four of the twleve questions were altered. Given that the questions are not weighted differently the modifications should not affect the internal consistency of the ACL-RSI however the measurement properties of the adapted scale were not assessed. Further research into normal ACL-RSI responses is required for populations outside of the cohort studied here. This includes non-field sport athletes and female populations who have a higher incidence of ACL injury (Voskanian, 2013) especially as gender has recently been shown to be a significant factor in not returning to sport after ACLR (Kate E. Webster, Nagelli, Hewett, & Feller, 2018). In addition the factors influencing submaximal scores in the uninjured population should be explored to identify potential areas for intervention.

5. Conclusion

This study provides baseline ACL-RSI scores for a cohort of healthy, male, field sport athletes for the first time. Despite no previous injury the control group had submaximal scores perhaps reflecting an pre-existing awareness of ACL injury even among healthy athletes. It also demonstrated a small magnitude difference between ACL-RSI scores of this matched healthy cohort and subjects nine-months after ACLR. These results provide a baseline for clinicians during rehabilitation and for future intervention studies.

Conflicts of interest

The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article.

No conflict of interest.

Ethical approval

Ethical approval for this study was obtained from the Clinical Research Ethics Committee at University College Cork ECM 6 (c) 17/10/17 (Appendix C.) and from the Hospital Ethics Committee at the Sports Surgery Clinic in Dublin (25-AFM-010).

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2019.05.006.

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