BMJ Open Sport & Exercise Medicine

Psychological readiness for injury recovery: evaluating psychometric properties of the IPRRS and assessing group differences in injured physically active individuals

Alexandra Dluzniewski ,[1] Madeline P Casanova ,[1] Sarah Ullrich-French ,[2] Christopher J Brush ,[3] Lindsay W Larkins ,[3] Russell T Baker [1,3]

To cite: Dluzniewski A, Casanova MP, Ullrich-French S, *et al.* Psychological readiness for injury recovery: evaluating psychometric properties of the IPRRS and assessing group differences in injured physically active individuals. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e001869. doi:10.1136/bmjsem-2023-001869

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjsem-2023-001869).

Accepted 6 June 2024

[1]WWAMI Medical Education, University of Idaho, Moscow, Idaho, USA
[2]Washington State University, Pullman, Washington, USA
[3]Movement Sciences, University of Idaho, Moscow, Idaho, USA

Correspondence to
Dr Russell T Baker; russellb@uidaho.edu

ABSTRACT

Objectives The primary purpose of the study was to assess the one-factor and two-factor structure of the Injury Psychological Readiness to Return to Sport Scale (IPRRS) in an injured physically active population using confirmatory factor analysis (CFA) procedures and assess group (ie, sex, age, injury type, athlete status) and longitudinal differences using structural equation modelling (eg, invariance testing).

Methods The non-experimental study included a sample of 629 physically active individuals who suffered a musculoskeletal injury who sought treatment at an outpatient integrated sport medicine and rehabilitation therapy clinic. Participants filled out a questionnaire packet at three time points. Data analysis included a CFA and multigroup and longitudinal invariance.

Results Sample mean age was 26.3 years, with females comprising 49.5%. Chronic injuries represented 29.6% of the sample and 35.0% were classified as competitive athletes. A six-item, one-factor model was confirmed in the sample with factor loadings ranging from 0.67 to 0.86. Multigroup and longitudinal invariance were established. Multigroup invariance demonstrated null differences between sex and injury type, and statistical differences between age and athlete status subgroups. Longitudinal invariance demonstrated a statistically significant increase in psychological readiness over time.

Conclusions The findings support the use of the IPRRS as a tool to measure aspects of psychological readiness. Clinicians and researchers can use the IPRRS to assess interventions in future research.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Psychological readiness is the presence of confidence and lack of fear and is crucial to safely returning to sport after injury. The Injury Psychological Readiness to Return to Sport Scale (IPRRS) is one of the most used scales to measure psychological readiness; however, conflicting evidence of its psychometric properties exists.

WHAT THIS STUDY ADDS

⇒ Structural validity of the IPRRS in a new population (ie, non-competitive physically active individuals) which is relevant for practitioners who do not work with competitive athletes. Our study offers support for multigroup and longitudinal invariance, supporting the use of the IPRRS as a comparative tool across time and the identified subgroups. Our study demonstrated that competitive athletes and adolescents scored the highest on the IPRRS at baseline, and short-term and long-term injury subgroups scored similarly on the IPRRS at baseline.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study establishes that changes in psychological readiness can be measured with the IPRRS, which provides clinicians and researchers with a valuable tool for intervention studies examining this phenomenon. However, the IPRRS includes items that only capture confidence, and inclusion of a fear-based instrument is needed to fully capture the phenomenon of psychological readiness.

INTRODUCTION

Physical activity can be defined as any bodily movement that requires energy expenditure (WHO, 2024) and is integral to physical, mental and overall well-being.[1 2] Approximately 50 million Americans participate in hiking and approximately 60 million people participate in jogging, running and trail running.[3] While physical activity has numerous benefits, injuries may occur. An estimated 8.6 million non-emergency sports-related and recreation-related injuries occur annually, leading to 3.8 million emergency room visits.[4]

Healthcare providers play a crucial role in guiding patients through recovery after injury. The aim is to facilitate a timely return to activity while minimising the risk of reinjury and negative psychological impact, such as increased anxiety.[5 6] Providers use impairment-based markers (eg, muscle strength, range of motion)[5 6] along with patient-reported outcome measures (PROMs)[5 6] to monitor and guide return-to-activity decisions. Assessing psychological variables, like psychological readiness, is essential for gauging a patient's preparedness to return to activity.[5 6] Neglecting psychological readiness may lead to increased reinjury risk, decreased performance and adverse effects on mental health.[7–10] Therefore, providers should include psychological PROMs in their assessments alongside disease-oriented variables to inform care decisions and determine the appropriate timing for a return to activity.

Psychological readiness lacks a widely accepted definition[7 8]; however, the presence of confidence and an absence of fear and anxiety are recognised as essential markers in determining psychological readiness to return to sport.[7 9–11] Various questionnaires (eg, ACL Return to Sport after Injury Scale,[12] Causes of Re-Injury Worry Questionnaire,[13] Athlete Fear Avoidance Questionnaire[14]) have been designed to measure psychological readiness to return to sport, but most are limited to specific injury groups or may not encompass essential markers of psychological readiness (eg, confidence). The Injury Psychological Readiness to Return to Sport Scale (IPRRS) can be used across various injured populations to measure confidence to augment the fear-based instruments.[10]

A psychometrically sound scale should have a consistent factor structure, which may be tested using a classic test theory (CTT) approach using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) procedures.[15 16] When using a CTT approach to determine the underlying latent factors, it is recommended performing an EFA and then a subsequent CFA in a separate sample after an initial factor structure has been identified.[16 17] Because CTT is sample dependent, the factor structure needs to be established in each new sample.[16] Moreover, identified factors should meet recommended Cronbach's α levels. Low α levels (ie, ≤0.70) indicate poor internal consistency, while high α levels (≥0.90) likely indicate item redundancy, construct under-representation, reduce construct precision or parallel items.[18] Further, when choosing appropriate sample size to sufficiently power factor analysis, it is ideal to have at least a 20:1 (ie, number of participants to number of items) ratio.[16]

While preliminary research provided some evidence for sound measurement properties (eg, test–retest reliability) of the IPRRS, multiple areas of concern have also been identified. For example, factor structure analyses of the IPRRS in different populations using different analysis approaches[8 19 20] have yielded mixed solutions. One study using principal components analysis on a sample of 100 Persian athletes produced a two-factor solution with two items representing a 'confidence to play' factor and four items representing a 'confidence in the injured body part and skill level' factor,[19] while another used EFA on a sample of 150 Dutch athletes suffering an ACL injury and produced a one factor, six-item solution.[20] Another study that performed CFA on a sample of 100 Italian athletes was used to test two models: poor fit was found for the one factor, six-item model, while more acceptable fit was found for a two-factor model with each factor represented by three items.[8] Lastly, internal consistency of the factors has been mixed with some meeting recommended values,[8] while others had values outside the range (ie, 0.63; 0.94)[19 20]

Further psychometric analysis to establish the measurement properties of the IPRRS is needed, including using larger, more diverse (eg, recreational vs competitive athletes) samples to conduct multigroup and longitudinal invariance testing.[16 21] Larger sample sizes (>200) would more appropriately support analysis procedures and accurately represent the intended population.[16] Multigroup invariance testing ensures factorial stability across relevant subgroups (eg, sex, age, activity type), which indicates subsequently identified group differences are outside of measurement bias or scale error.[15 16 22] Sex, age, injury type and athlete status were chosen for subgroup analysis, because they can influence the injury process (ie, injury occurrence, injury response, injury recovery).[7 11] Sex and age can influence psychological responses to injury and readiness to return to sport due to biological and developmental differences.[11 23] Injury type can impact psychological readiness through variations in recovery processes and perceived severity.[7] Athlete status may influence psychological readiness as competitive athletes may experience different pressures and expectations compared with recreational athletes.[7]

Similarly, longitudinal invariance testing supports repeated use of the scale to assess change over time and establishes that factors are adequately measured across repeated testing.[15 16 22] Therefore, the purpose of the study was to assess the factor structure of the IPRRS in a sample of physically active individuals by using CFA. Invariance testing will be used to further establish measurement properties of repeated use (ie, longitudinal invariance) and between groups (ie, multigroup invariance). Further, invariance testing will provide the ability to compare mean differences between groups and across time.

METHODS

Patient and public involvement

Patients and the public were not involved in the process of recruitment, data collection and data analysis of this research.

Procedure

The outcome measures packets were collected from September 2020 to May 2022 in physically active individuals with musculoskeletal injuries undergoing treatment at an outpatient rehabilitation clinic and multiple athletic training clinics across the USA. Patients provided informed consented and completed the packet during

Table 1 Study definitions and terminology[6]

Terminology	Definition
Physically active	An individual who engages in athletic, recreational or occupational activities that require physical skills and who uses strength, power, endurance, speed, flexibility, range of motion or agility at least 3 days per week.
Injury classification	
Healthy	Free from musculoskeletal injury and fully able to participate in sport or activity.
Acute injury	A musculoskeletal injury that precludes full participation in sport or activity for at least 2 consecutive days (0–72 hours post-injury).
Subacute injury	A musculoskeletal injury that precludes full participation in sport or activity for at least 2 consecutive days (3 days–1 month post-injury).
Persistent injury	A musculoskeletal injury that has been symptomatic for at least 1 month.
Chronic injury	Pain that consistently does not get any better with routine treatment or non-narcotic medication and has been occurring for at least 1 month.
Injury severity	
Mild	Relatively normal clinical examination (ie, minimal examination findings), recovery expected quickly (ie, ≤72 hours).
Moderate	Examination findings (eg, mild brushing/swelling/etc, noticeable loss of strength or ROM, etc); recovery expected 7–14 days.
Severe	Substantial examination findings (eg, considerable brushing/swelling/etc, loss of function, etc); recover expected 7–14 days.
Activity level classification	
Extremely low	No activity beyond baseline activity (baseline activity refers to 'light-intensity activities (eg, standing, walking, lifting weighted objects) of daily life).
Low	Activity beyond baseline, but fewer than 150 min of moderate-intensity exercise per week (moderate activity includes activities such as brisk walking, yoga, lifting weights, etc).
Medium	150–300 min of moderate-intensity activity per week'
High	More than 300 min of moderate-intensity activity per week.
Physical activity status	
Competitive athlete	A participant who engages in a sport activity that requires at least 1 pre-participation examination, regular attendance at scheduled practices and/or conditioning sessions and a coach who leads practices and/or competitions.
Recreational athlete	Participants who meet the criteria for physical activity and participate in sport, but do not meet the criteria for competitive status.
Occupational athlete	Participants who meet the criteria for physical activity in occupation or recreation, but do not meet the criteria for competitive or recreational athlete.
Physically active in activities of daily living	Participants who do not meet the criteria for any 'athlete' category, but who are physically active through their daily activities (eg, physically active for at least 30 min per day, 3 days per week).

ROM, range of motion.

the initial visit to the clinic; when necessary, legal guardians provided consent and minors provided assent.

Participants

The sample consisted of physically active participants who suffered from a musculoskeletal injury. Inclusion criteria were being physically active and suffering an injury (table 1). Participants self-reported their current physical activity level (ie, high, medium, low, inactive) and were categorised into a physical activity level by the attending clinician. The attending clinician categorised injury subtype and injury severity with the patient (table 1). Participants were categorised based on stages of human development (ie, middle childhood: 5 –11 years old; adolescent: 12–17 years old; emerging adulthood: 18–25 years old; young adulthood: 26–40 years old; middle adulthood: 41–65 years old; late adulthood: >66 years old).[24]

Instrumentation

Study packets, administered at three visits, included a demographic section, questionnaires measuring physical attributes of injury (eg, pain) and the IPRRS. The IPRRS[10] is a six-item scale measuring confidence to return to sport post-injury (eg, 'confidence to play without pain') using a 0–100 scale (0='no confidence', 50='moderate confidence', 100='utmost/complete confidence') to rate each item; scores are summed and divided by 10 for a total score. A score of 60 represents high confidence, 40 represents moderate confidence and 20 represents low confidence.[10] The IPRRS has demonstrated internal consistency of α=0.78–0.93[10] and excellent test–retest reliability (intraclass correlation coefficient=0.89).[20] Participants, guided by clinicians, completed the study packet at the initial visit prior to treatment, with follow-up visits scheduled based on injury type: acute/subacute injury group had follow-up visits at 3–5 days (visit 2) and 7–10 days (visit 3) post-initial visit, and the persistent/chronic injury group had follow-up visits at 7–10 days (visit 2) and 3 weeks (visit 3) post-initial visit.[5 6] Thus, minimum length of protocol was 10 days and maximum length was 31 days.

Data analysis plan

De-identified data were entered into Qualtrics by a healthcare team member and later analysed using SPSS (IBM SPSS Statistics for Windows, V.27.0) and Analysis of Moment Structure (AMOS, SPSS) V.27. Typically, missing ≥10% of data are considered significant, and missing only one item on the IPRRS would be missing 15% of the responses to the scale; therefore, we allowed for only one missing item on the IPRRS[16 25] and participants' missing responses to more than one item were excluded. If missing data exceeded 5%, a missing completely at random test was performed ($p<0.001$); less than 5% missing data were considered negligible and were imputed using mean imputation.[16] Individuals with missing demographic variables were retained. Data normality was then assessed via histograms, skewness and kurtosis values, and outliers using z-scores and Mahalanobis distance; those with individual item z-scores greater than |3.3| or Mahalanobis cut-off scores exceeding multivariate normality were removed.[16 25] For longitudinal invariance, participants not responding to the IPRRS at all three visits were excluded from the analysis.

Scale structure

Following data cleaning, a CFA was conducted using maximum likelihood estimation in AMOS, to confirm a one or two-factor model identified in previous literature. Factor structure was assessed by using the following guidelines: (a) factor loadings ≥0.40, (b) bivariate correlations ≤0.80, (c) internal consistency (≥0.70, ≤0.89) and (d) item content.[15 17 18 25] Further, model fit was assessed by evaluating the following fit indices[16 21 26]: Comparative Fit Index (CFI; ≥0.95), Tucker-Lewis Index (TLI; ≥0.95), Root Mean Square Error of Approximation (RMSEA; ≤0.06) and Bollen's Incremental Fit Index (IFI; ≥0.95). While RMSEA is a common criterion to assess, it is sensitive to low df[27]; therefore, Standardized Root Mean Square Residual (SRMR) was given greater weight in model fit. Additionally, while the likelihood ratio statistic was assessed, it is not as informative as the other fit indices due to it being overly sensitive to sample size.[15 16] To identify any localised area of strain, other parameters were examined, including significance of factor loadings and covariances, and indicator errors that result in modification indices greater than 10.[15 16 21]

Invariance testing

The full sample was used to conduct multigroup and longitudinal invariance testing. The purpose of invariance analysis is to assess validity across subgroups of interest and across time. A series of hierarchical steps was conducted to establish multigroup and longitudinal invariance: configural invariance (ie, equal forms), metric invariance (ie, equal loadings and equal intercepts) and scalar invariance (ie, equal factor variances and equal factor covariance).[16 21]

The same fit indices for CFA were used to assess invariance models. Invariance was evaluated based on CFI difference (CFI_{DIFF}) of less than 0.01, and X^2 difference test (X^2_{DIFF}) with a p value cut-off of 0.01.[15 16] However, the CFI_{DIFF} held greater weight in assessing invariance due to X^2 being sensitive to sample size.[15 16] Multigroup invariance was conducted across sex, injury status and activity levels. Longitudinal invariance was assessed on injured participants across three time points. Latent group mean scorers were evaluated with statistical significance set at $p\leq0.05$; Cohen's d effect sizes were calculated and assessed using the guidelines of d=0.2 as a small effect size, d=0.5 as a medium effect size and d=0.8 as a large effect size.[28]

RESULTS

Of the 631 cases, 37 with 100% missing IPRRS data were deleted. Eight cases missing only one item (0.20% of the data) were retained and missing values were replaced with the mean score.[16] Skewness was observed for items 1, 3 and 5; however, transformation was not applied because of evidence suggesting minimal benefit in psychometric analysis.[29] No univariate and multivariate outliers were identified. Two participants were under the age of 12 years and were not included in the analysis; thus, 592 cases were used for analysis. Sample mean age was 26.3±13.05 years (range: 12–76 years), with females comprising 49.5% and males 49.0%. Chronic injuries represented 29.6% of the sample and 35.0% were classified as competitive athletes. Full demographics are presented in table 2.

Confirmatory factor analysis

The original proposed six-item, one-factor model of the IPRRS (figure 1) was tested using responses from the initial visit. Model fit indices met recommended values (CFI=0.97; $\chi2$ (9)=67.38; TLI=0.96; IFI=0.97; SRMR=0.03; RMSEA=0.11) and had significant factor loadings ($p<0.01$) that ranged from 0.67 to 0.86. Internal consistency exceeded the recommended value range (α=0.91 and ω=0.91), indicating potential item redundancy, but item removal would not have lowered values within the recommended range.

The six-item, two-factor model of the IPRRS (online supplemental figure 1) was tested at baseline and model fit met recommended values (CFI=0.99, $\chi2$ (8)=38.61, TLI=0.97; IFI=0.99; SRMR=0.02; RMSEA=0.08). While the two-factor model met general fit recommendations, the correlation between the two factors was 0.94 with the

Table 2 Demographic statistics

Characteristics	N	%
Sex		
Male	290	49.0
Female	293	49.5
Prefer not to answer	1	0.7
Unknown	8	1.4
Age		
Middle childhood	2	0.3
Adolescent	102	17.2
Emerging adulthood	290	49.0
Young adulthood	109	18.4
Middle adulthood	68	11.5
Late adulthood	11	1.9
Unknown	10	1.7
Ethnicity		
White/Caucasian	469	79.2
Black/African American	29	4.9
Hispanic/Latino	41	6.9
Asian	21	3.5
Pacific Islander	7	1.2
Other	11	1.9
Unknown	14	2.4
Physical activity status		
Competitive athlete	207	35.0
Recreational athlete	158	26.7
Occupational athlete	71	12.0
Activities of daily living	130	22.0
Unknown	26	4.4
Injury status		
Acute injury	148	25.0
Subacute injury	152	25.7
Persistent injury	90	15.2
Chronic injury	175	29.6
Unknown	27	4.6

first factor accounting for 68.8% of the variance and the second factor accounting for 10.2% of the variance. A high correlation between the latent variables is evidence of multicollinearity,[16 21] suggesting unique latent variables are not being measured. Therefore, subsequent analyses were conducted on the one-factor model.

Multigroup invariance

Sex group analysis

A total of 583 individuals reported their sex (males=290, females=293) at baseline and were used for analysis; each model met recommended fit values, which supported assessing a configural model (online supplemental table 1). The configural model (ie, equal form) met recommended fit values (CFI=0.97; χ2 (18)=78.15; TLI=0.95; IFI=0.97; SRMR=0.04,; RMSEA=0.08). The metric and scalar models passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating males and females interpret the items and construct similarly, which supported measurement invariance. Thus, steps to compare latent variance and mean scores were performed. The equal latent variances and equal means model passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating that males and females did not have significantly different variance or mean scores on the IPRRS at baseline.

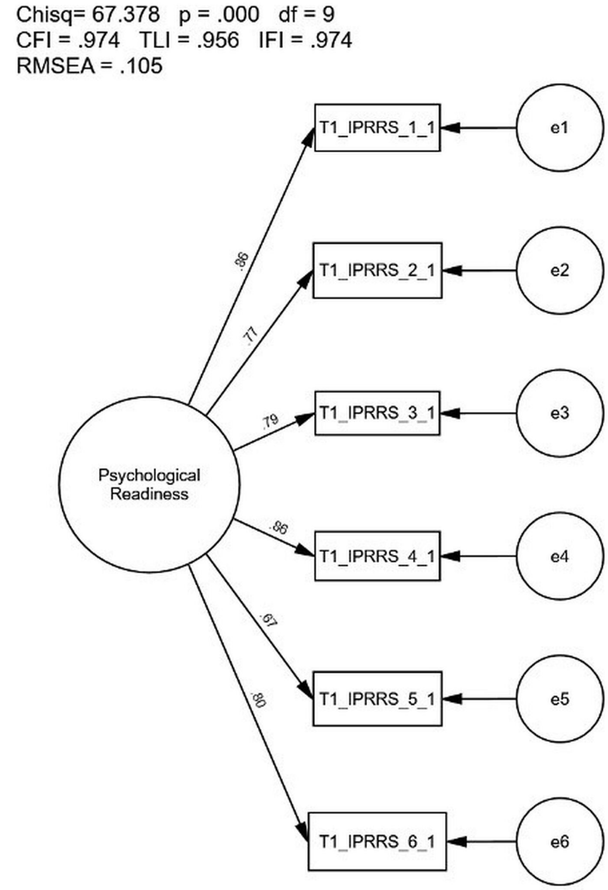

Figure 1 One-factor, six-item model of the IPRRS. All factor loadings were significant at p<0.001. CFI, Comparative Fit Index; e, error; IFI, Bollen's Incremental Fit Index; IPRRS, Injury Psychological Readiness to Return to Sport Scale; RMSEA, Root Mean Square Error of Approximation; T1, visit 1; TLI, Tucker-Lewis Index.

Age group analysis

A total of 582 participants reported their age (M=26.58±13.48). Two of the age categories (ie, middle childhood and late adulthood category) were excluded from the analysis due to the small subsample size (n=2 and n=11, respectively). Baseline models for each age group met recommended fit values, which supported assessment of a configural model (online supplemental table 2). The configural model met recommended fit values (CFI=0.97; χ2 (18)=90.73; TLI=0.96; IFI=0.97; SRMR=0.05; RMSEA=0.04). Subsequent models (ie, metric, scalar) passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating age groups interpreted the items similarly, which supported measurement invariance and equal latent variance and equal means models could be tested for substantive group differences. The equal latent variance model passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating variances were similar between age groups. The equal means model did not pass the CFI_{DIFF} test, indicating mean scores between age groups were statistically different. When means were not constrained to be equal, the adolescent age group had significantly higher scores (M_{DIFF}=10.78, p<0.001, effect size=0.54) on the IPRRS than all other age groups.

Injury group analysis

A total of 565 individuals' injury category was recorded at baseline and they were used for analysis (persistent/chronic n=265; acute/subacute n=300). The persistent/chronic injury group had an overall mean age of 28.97 years±14.55 and primarily consisted of females (56.6%), non-athletes (40.1%) and the emerging adulthood age group (48.3%). The acute/subacute injury group had an overall mean age of 24.22 years±11.15 and primarily consisted of males (53.1%), competitive athletes (41.9%) and the emerging adulthood age group (48.9%). A breakdown of the demographics for injury groups is presented in online supplemental table 3.

All baseline models for injury group met recommended fit indices (online supplemental table 4). The configural model also met recommended fit values (CFI=0.96; χ2 (36)=123.13; TLI=0.93; IFI=0.96; SRMR=0.04; RMSEA=0.06). Subsequent models (ie, metric, scalar) passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating injury groups interpreted the items similarly, which supported measurement invariance and allowed for the analysis of an equal latent variance and equal means models. The equal latent variance and equal means model passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating variances and means were not significantly different between injury groups.

Physical activity status analysis

A total of 566 individuals reported their physical activity status (competitive=207, recreational=158, non-athlete=201) at baseline and were used for analysis. The competitive athlete group had an overall mean age of 19.20±6.57 and was primarily composed of females (52.4%), acute/subacute injury (66.3%) and the emerging adulthood age group (50.4%). On the other hand, the recreational athlete group had an overall mean age of 30.44.±13.68 and was primarily composed of males (53.1%), the emerging adulthood age group (48.9%), and there was an even split in chronic/persistent and acute/subacute injury (50.0%). Conversely, the non-athlete subcategory had an overall mean age of 31.15 years±14.32 and was primarily composed of females (50.5%), chronic/persistent injury (57.5%) and the emerging adulthood age group (49.5%). A breakdown of the physical activity status subgroups is presented in online supplemental table 5.

All baseline physical activity status models met recommended fit indices (online supplemental table 6). The configural model met recommended fit criteria (CFI=0.97; χ2 (27)=102.41; TLI=0.94; IFI=0.97; SRMR=0.04; RMSEA=0.07). Subsequent models (ie, metric, scalar) passed both the χ^2_{DIFF} test and CFI_{DIFF} test, which supported measurement invariance, and the analysis of an equal variance and equal means models was performed. The equal latent variance model passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating variances were similar between physical activity groups. The equal means model did not pass the CFI_{DIFF} test, indicating means scores between physical activity status groups were statistically different. When means were not constrained to be equal, the competitive athlete group had significantly higher scores (M_{DIFF}=8.33, p<0.001, effect size=0.37) on the IPRRS than all other groups. The non-athlete and recreational athlete group scores on the IPRRS were not statistically different from each other.

Longitudinal Invariance

A total of 444 participants filled out the IPRRS at all three time points, with 11 participants missing one item which was replaced using mean imputation. Each time point model met recommended fit indices (online supplemental table 7). The configural model met recommended fit values (CFI=0.98; χ2 (114)=262.02; TLI=0.98; IFI=0.98; SRMR=0.04; RMSEA=0.05). The metric and scalar models passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating items were interpreted similarly across time, which support measurement invariance and warranted assessment of an equal latent variance and equal means model. The equal latent variance model passed both the χ^2_{DIFF} test and CFI_{DIFF} test, indicating variances were equal between groups. The equal means model did not pass the CFI_{DIFF} test, indicating mean scores across time were statistically different. When means were not constrained to be equal, all time points were significantly different from each other. The lowest score (ie, lowest levels of perceived confidence) on the IPRRS was at baseline (ie, time point one) scores subsequently improved with the highest score (ie, highest levels of perceived confidence) on the IPRRS (M_{DIFF}=18.01, p<0.001, effect size=0.75) occurring at time point three.

DISCUSSION

The purpose of this study was to assess measurement properties of the IPRRS in a diverse, heterogeneous physically active population undergoing treatment for musculoskeletal injury. Structural validity of the IPRRS was assessed to test proposed models, and multigroup and longitudinal invariance testing was conducted to reinforce structural validity and identify group or temporal differences.

Confirmatory factor analysis

Our CFA results align with previous research, indicating that the one-factor model was optimal,[8] warranting subsequent analysis. Model fit criteria were met[16 21] for both the one-factor and two-factor models in the study; however, the six-item, one-factor model displayed better fit for the IPRRS. The two-factor model had high correlation between the two factors, which indicates the presence of multicollinearity and that two factors are not measuring different constructs.[15 16 21] Our findings present similar one-factor and two-factor model findings in a larger, diverse sample of participants, further supporting the originally proposed model.[10] The findings of this study, as well as others,[17–19] supported invariance testing of the one-factor model.

Multigroup invariance

Multigroup invariance establishes measurement properties to allow testing of group differences (eg, psychological readiness differences across sexes) by ensuring participants interpret items and their meaning similarly.[15 16 21] The findings support multigroup (ie, sex, age, athlete status and injury type) invariance, which justifies group mean assessment. The practitioners and researchers may make inferences from IPRRS scores to assess for substantive group differences within these groups.

Our results, however, also provide insight into these potential group differences. For example, significant sex differences were not present in perceived psychological readiness as measured by the IPRRS at initial examination. While sex differences in psychological readiness had not been explored, researchers have reported that self-efficacy and helplessness were significantly higher in males than females after ACL surgery,[30] but not daily pain during rehabilitation post-ACL surgery in a physically active population.[7] Our findings support this work by establishing that the IPRRS can be used to examine psychological readiness differences between males and females and that meaningful differences were not found in our sample. Thus, in addition to psychological readiness, clinicians may want to focus more on helplessness for males and self-efficacy for females regarding response to injury. Future research should continue to explore the injury response process to better understand potential psychological readiness differences and how it relates to other relevant variables (eg, pain, kinesiophobia, resilience, social support) across sexes.

Significant group differences on IPRRS scores at visit 1 were not found for injury type (ie, persistent/chronic vs acute/subacute). The findings add to prior research that found chronicity of injury was more detrimental to quality of life and overall well-being compared with acute injury.[6 7 31] While injury duration may affect perceptions of well-being, it is not entirely surprising that injury type had not significantly affected IPRRS scores prior to care. The IPRRS assesses confidence in an individual's ability to participate in sport in relation to injury and an individual who recently sprained their ankle (ie, acute or subacute injury) or suffers from a persistent knee injury (eg, tendinitis) likely lacks similar confidence to perform sport function (eg, run) at initial examination.

Significant differences (M_{DIFF}=10.78, p<0.001, effect size=0.54) were found between age groups, with adolescents reporting the highest scores (eg, the most psychologically ready to return to sport) on the IPRRS at baseline examination. Additionally, significant differences were found for athlete status: competitive athletes (M_{DIFF}=7.61, p<0.003, effect size=0.33) scored higher on the IPRRS than recreational and non-athletes at the baseline examination. Because the adolescent age group is largely composed of competitive athletes, it is difficult to infer which demographic variable (ie, athlete status or age group) best explains or contributes to these differences. Injury appraisal may influence perceived psychological readiness, and this may be influenced by athletic history or life experience. For example, how athletes cope with injury is substantially influenced by how the situation is appraised[7 32]; six primary situational factors are thought to influence cognitive appraisal for athletes: novelty, predictability, uncertainty, temporal factors, ambiguity and when the event happens in the athlete's life cycle.[32]

Therefore, a potential explanation for these group differences could be that young athletes who are early on in their athletic career may appraise the situation more positively than older athletes, increasing young athletes' perceived psychological readiness[32] compared with older athletes. For example, researchers have reported that more experienced gymnasts were more fearful of injury compared with less experienced gymnasts.[33] Young athletes, who may lack experience with injury, may respond to pain and injury differently than older athletes whose previous experience with pain may trigger a heightened level of fear in older athletes who have suffered more sport injuries.[34] Less experience with injury may lower anxiety and fear associated with pain and injury which may lead to higher levels of psychological readiness. Past experiences with injury and pain, in contrast, may provide better knowledge and a more realistic expectation of the injury recovery process and a timeline for full recovery,[34] which could also explain the reduced psychological readiness scores in older athletes at initial examination. Future research should explore the potential relationship between injury history and psychological readiness.

The injury and recovery process may also be influenced by athletic participation status. For example, researchers have reported athletes have higher pain tolerance than non-athletes[7]; specifically, one of the areas that athletes differ from non-athletes is pain self-efficacy, which is the belief in their ability to be functional despite pain.[35] In the current study, IPRRS scores were significantly different between competitive athletes and the other groups; however, recreational athletes and non-athletes did not differ significantly, which may suggest that recreational athletes appraise injury similarly to non-athletes. Injury self-efficacy may be captured across multiple IPRRS items: 'confidence to play without pain', 'confidence in injured body part to handle the demands of the situation' and 'confidence to not concentrate on the injury'. Thus, it is possible the competitive athlete group had higher self-efficacy and the perception of being able to function despite the pain resulted in higher levels of perceived psychological readiness, which may explain some of the phenomena in addition to age and injury experience. While the findings may indicate age is a larger factor than athlete status, further research is needed to understand the mechanism by which age and athlete status influence psychological readiness and the recovery process.

Thus, the findings may contradict prior research suggesting younger athletes cope with injury poorly in comparison with older athletes.[7] However, the injury appraisal and recovery process are complex phenomena that are influenced by both situational and personal factors, as well as biopsychosocial factors.[7 30 32] Based on our findings, clinicians may want to focus more on how the injury is being appraised (eg, challenge vs threat) more than age or athlete status. Further, age may be a larger factor than athlete status, but further research is needed to understand the mechanism by which age and athlete status influence psychological readiness and the recovery process.

Longitudinal invariance

The study also provides novel insight by examining longitudinal invariance of the IPRRS. Longitudinal invariance established stability in the measurement parameters over time.[15 16 21] Thus, assessment of group means across time can be explored to determine if true change in psychological readiness was measured with the IPRRS. Study participants experienced significant (M_{DIFF}=18.01, p<0.001, effect size=0.75) improvement in IPRRS scores across time, with the lowest scores occurring at the initial visit and the highest scores occurring at the final visit. The findings support prior research that also found improvement on the IPRRS overtime[10] and are further supported by the correlational findings: meaningful improvement when receiving rehabilitation should occur, whether from the effects of treatment, natural healing or placebo, and this improvement should come across scales (eg, IPRRS, numeric pain rating scale (NPRS)) resulting in stronger correlations between the scales across time.

Clinical implications

Clinicians and researchers may use the IPRRS to assess psychological readiness following musculoskeletal injuries. The multigroup and longitudinal invariance results provide support for using the IPRRS as part of testing to better understand group differences and changes across time, which may lead to better tailored interventions post-injury. For example, clinicians may want to focus on the heightened anxiety and fear older athletes may experience compared with younger athletes to improve psychological readiness at baseline. Additionally, the IPRRS can be used to track progress in psychological readiness throughout the rehabilitation process, which can inform patient care and help to optimise recovery.

Limitations and future research

The current study has some limitations to consider. While the IPRRS met most contemporary psychometric recommendations, it does demonstrate potential redundancy and all psychometric properties (eg, test–retest reliability) were not examined in this study. Additionally, the IPRRS only measures confidence to return to activity after injury without assessing fear and anxiety, which are proposed components of a broad view of psychological readiness.[7] Thus, comprehensive evaluation of psychological readiness may not be possible with use of the IPRRS in isolation and clinicians may consider using an instrument to measure fear and anxiety components alongside the IPRRS to better assess psychological readiness. Development of a more comprehensive psychological readiness (eg, fear of movement) instrument would be beneficial to reduce response burden and improve clinical applicability of the available measures for clinicians who want to measure psychological readiness as part of the injury recovery process.

Further, the adolescent age group was not heterogeneous in terms of physical activity status. Due to unequal group sizes for physical activity status by age, it was difficult to determine if the differences found between age groups and physical activity status were more influenced by age or physical activity status. Additionally, other relevant variables (eg, history of injuries, patients' expectation for healing, patients' attitude toward the injury) for understanding perceived psychological readiness were not collected and these factors could influence psychological readiness or differ across groups. Future research should examine how other relevant demographic (eg, age, physical activity status, injury history), physical and psychological variables impact psychological readiness.

While the study did include longitudinal analysis and differences were found across time, the study did not control for the types of injury, intervention received, or rehabilitation adherence or protocol (eg, multimodal therapy vs single-intervention therapy, visit duration, visit regularity, etc) and the study did not have a control group. Thus, it is not possible to determine the mechanism accounting for improvements in psychological readiness and if psychological readiness was different across groups (eg, treatment groups). Further, as the initial IPRRS scores were taken post-injury, it is not possible to know how other variables (eg, mindsets, attitudes, etc) altered perceived psychological readiness before, during or after the injury or rehabilitation process. Future research should examine how these other variables potentially influence perceived psychological readiness during physical activity and through the injury recovery process.

CONCLUSION

This study supported IPRRS structural validity as a one-factor, six-item model, and established measurement invariance for the IPRRS across groups (ie, sex, age, injury type and physical activity) and time, allowing clinicians to use the IPRRS across these groups and across time. Significant baseline differences in psychological readiness were not found for sex or injury type but were found across age and physical activity status. Significant improvement in IPRRS scores was also found across visits, and future research should include other relevant variables to better understand mechanisms of change in psychological readiness post-injury. Clinicians may use the IPRRS to augment fear and anxiety assessments to measure multiple dimensions of psychological readiness post-injury. Lastly, how individuals appraise their injury may be more impactful on their psychological readiness than age or athlete status.

Contributors Guarantor—RTB. Conceptualisation—AD, RTB, MPC, SU-F, CJB and LL. Methodology—AD, RTB and MPC. Formal analysis—AD, MPC, SU-F and CJB. Resources—AD, MPC and RTB. Data curation—RTB, AD and MPC. Writing (original draft preparation)—AD, RTB and MPC. Writing (review and editing)—RTB, SU-F, CJB, LL, MPC and AD. Supervision—RTB and MPC. All authors approved the final submitted version.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the University of Idaho Institutional Review Board (#16-149). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data can be made available upon reasonable request.

ORCID iDs
Alexandra Dluzniewski http://orcid.org/0009-0000-0477-5098
Madeline P Casanova http://orcid.org/0000-0001-8383-3232
Sarah Ullrich-French http://orcid.org/0000-0002-4666-3067
Christopher J Brush http://orcid.org//0000-0002-8622-2610
Lindsay W Larkins http://orcid.org/0000-0001-5130-5355
Russell T Baker http://orcid.org/0000-0003-3352-9632

REFERENCES

1 Stuart JH. Biddle. In: *Psychology of physical activity: determinants, well-being and interventions*. Routledge, 2001.
2 Kim ES, Kubzansky LD, Soo J, *et al*. Maintaining healthy behavior: a prospective study of psychological well-being and physical activity. *Ann Behav Med* 2017;51:337–47.
3 Lange D. Physical activity - statistics and facts. Statista; 2022. Available: https://www.statista.com/topics/1749/physical-activity/#topicHeader__wrapper
4 National Safety Council. NSC injury facts. sport and recreational injuries. 2022. Available: https://injuryfacts.nsc.org/home-and-community/safety-topics/sports-and-recreational-injuries/
5 Baker RT, Burton D, Pickering MA, *et al*. Confirmatory factor analysis of the disablement in the physically active scale and preliminary testing of short-form versions: a calibration and validation study. *J Athl Train* 2019;54:302–18.
6 Vela LI, Denegar CR. The disablement in the physically active scale, part II: the psychometric properties of an outcomes scale for musculoskeletal injuries. *J Athl Train* 2010;45:630–41.
7 Brewer BW, Redmond CJ. *Psychology of sport injury*. In: *Human kinetics*. 2017.
8 Conti C, di Fronso S, Robazza C, *et al*. The injury-psychological readiness to return to sport (I-PRRS) scale and the sport confidence inventory (SCI): a cross-cultural validation. *Phys Ther Sport* 2019;40:218–24.
9 Ardern CL, Taylor NF, Feller JA, *et al*. A systematic review of the psychological factors associated with returning to sport following injury. *Br J Sports Med* 2013;47:1120–6.
10 Glazer DD. Development and preliminary validation of the injury-psychological readiness to return to sport (I-PRRS) scale. *J Athl Train* 2009;44:185–9.
11 Podlog L, Banham SM, Wadey R, *et al*. Psychological readiness to return to competitive sport following injury: a qualitative study. *Sport Psychol* 2015;29:1–14.
12 Webster KE, Feller JA, Lambros C. Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. *Phys Ther Sport* 2008;9:9–15.
13 Christakou A, Zervas Y, Stavrou NA, *et al*. Development and validation of the causes of re-injury worry questionnaire. *Psychol Health Med* 2011;16:94–114.
14 Dover G, Amar V. Development and validation of the athlete fear avoidance questionnaire. *J Athl Train* 2015;50:634–42.
15 Brown T. *Confirmatory factor analysis for applied research*. 2nd Ed. Guilford Publications, 2015.
16 Kline RB. *Methodology in the social sciences. Principles and practice of structural equation modeling*. 4th Ed. Guilford Publications, 2016.
17 Matsunaga M. How to factor-analyze your data right: do's, don'ts, and how-to's. *Int J Psychol Res* 2010;3:97–110.
18 Streiner DL. Starting at the beginning: an introduction to coefficient alpha and internal consistency. *J Pers Assess* 2003;80:99–103.
19 Naghdi S, Nakhostin Ansari N, Farhadi Y, *et al*. Cross-cultural adaptation and validation of the injury-psychological readiness to return to sport scale to persian language. *Physiother Theory Pract* 2016;32:528–35.
20 Slagers AJ, Reininga IHF, Geertzen JHB, *et al*. Translation, cross-cultural adaptation, validity, Reliability and stability of the dutch injury - psychological readiness to return to sport (I-PRRS-NL) scale. *J Sports Sci* 2019;37:1038–45.
21 Byrne BM. *Structural equation modeling with AMOS: basic concepts, applications, and programming*. 3rd Ed. Routledge, 2016.
22 Chen FF. Sensitivity of goodness of fit indexes to lack of measurement Invariance. *Struct Equ Model Multidiscip J* 2007;14:464–504.
23 Wiese DM, Weiss MR. Psychological rehabilitation and physical injury: implications for the sportsmedicine team. *Sport Psychol* 1987;1:318–30.
24 Sigelman CK, Rider EA. *Life-span human development*. Cengage Learning, 2014.
25 Leech NL, Barrett KC, Morgan GA. *IBM SPSS for Intermediate statistics: use and interpretation*. 5th Ed. Routledge/Taylor & Francis Group, 2015.
26 Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Model Multidiscip J* 1999;6:1–55.
27 Kenny DA, Kaniskan B, McCoach DB. The performance of RMSEA in models with small degrees of freedom. *Sociol Methods Res* 2015;44:486–507.
28 Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd Ed. 1988.
29 Tabachnick BG, Fidell LS. *Using multivariate statistics*. 4th Ed. Allyn & Bacon, 2001.
30 Lisee CM, DiSanti JS, Chan M, *et al*. Gender differences in psychological responses to recovery after anterior cruciate ligament reconstruction before return to sport. *J Athl Train* 2020;55:1098–105.
31 Ramírez-Maestre C, Esteve R, López AE. Cognitive appraisal and coping in chronic pain patients. *Eur J Pain* 2008;12:749–56.
32 Lazarus RS, Folkman S. *Stress, appraisal, and coping*. Springer Publishing Company, 1984.
33 Cartoni AC, Minganti C, Zelli A. Gender, age, and professional-level differences in the psychological correlates of fear of injury in Italian gymnasts. *J Sport Behav* 2005;28:3–17.
34 Lethem J, Slade PD, Troup JDG, *et al*. Outline of a fear-avoidance model of exaggerated pain perception—I. *Behav Res Ther* 1983;21:401–8.
35 Ghazaie M, Tajikzadeh F, Sadeghi R, *et al*. The comparison of pain perception, coping strategies with pain and self-efficacy of pain in athlete and non-athlete women. *JFMH* 2015;17.