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ASSESSMENT PROCEDURE

Reliability and validity of the Brief Pain Inventory-Short Form in individuals with rotator cuff-related shoulder pain

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ABSTRACT

Purpose: To investigate the test–retest reliability and construct validity of the Brief Pain Inventory-Short Form (BPI-SF) in individuals with rotator cuff-related shoulder pain (RCRSP).

Methods: Sixty-one participants with RCRSP completed the BPI-SF twice with an interval of two to seven days and Shoulder Pain and Disability Index (SPADI) at the initial visit. The BPI-SF pain severity subscale, pain interference subscale, and stand-alone pain severity items were analysed using intraclass correlation coefficients (ICCs) and minimal detectable change at the 95% confidence interval (MDC_{95}). The construct validity of BPI-SF was assessed against SPADI using Pearson's correlation.

Results: The BPI-SF pain severity and pain interference subscales presented moderate test–retest reliability (ICC = 0.73, 0.53) and MDC_{95} were 2.05 and 2.36. All stand-alone BPI-SF pain severity items presented a moderate reliability (ICC = 0.62, 0.70). BPI-SF interference items presented poor to moderate reliability (ICC = 0.39, 0.68). The correlation coefficients between the BPI-SF and SPADI subscales or total scores were large (r = 0.61, 0.75).

Conclusions: BPI-SF pain severity and pain interference subscales have a moderate reliability in individuals with RCRSP. BPI-SF pain severity and interference subscales showed high construct validity in individuals with RCRSP. MDC_{95} values are useful metrics for interpreting a true change in BPI-SF scores following interventions in individuals with RCRSP.

IMPLICATIONS FOR REHABILITATION

- Our findings support the use of the Brief Pain Inventory-Short Form (BPI-SF) pain severity and interference subscales in patients with rotator-cuff related shoulder pain (RCRSP).
- Our findings support the use of the stand-alone pain severity item (i.e., "worst pain") in individuals with RCRSP.
- The BPI-SF has good construct validity in individuals with RCRSP.

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KEYWORDS
Rotator cuff; shoulder pain; brief pain inventory; reliability; validity

Introduction

Shoulder pain is the third most common musculoskeletal complaint in people presenting to primary care practitioners [1,2]. Most frequently, shoulder pain can be attributed to structures within the subacromial space, falling under the umbrella term, rotator cuff-related shoulder pain (RCRSP) [3–5]. The RCRSP refers to pain that originates from the muscles, tendons, and surrounding structures, such as bursa, bone, ligament, capsule, nerve, and vascular tissue related to the entirety of the rotator cuff [6]. The hallmark sign of RCRSP is pain during active shoulder elevation or external rotation [6,7]. Consequently, individuals experiencing RCRSP struggle to participate in occupational and general daily activities, creating a significant burden at personal and societal levels [8]. Therefore, measuring the symptoms associated with RCRSP is essential to optimise clinical outcomes and the accuracy of research in this population.

Pain experience, emotional function, and physical function are interdependent constructs within the biopsychosocial model of pain [9]. Therefore, all three should be assessed in individuals with RCRSP to accurately measure the impact of the condition. Moreover, pain and its impact on function are subjective experiences; hence, both must be measured via self-reporting [10]. Consequently, the Brief Pain Inventory-Short Form (BPI-SF) may be ideal for assessing individuals with RCRSP. The BPI-SF is a widely used patient-reported outcome measure that assesses pain and its impact on function across two subscales: pain severity and pain interference [11]. The questions within the pain severity subscale are suggested to be ideal for randomised controlled trials as stand-alone items [12]. Additionally, the pain interference questions assess function across multiple domains of normal life [11]. Furthermore, the brevity of the BPI-SF, its ease of understanding and marking, and its demonstrated validity across multiple languages bolster its utility in people with chronic pain [13–16].

The reliability and validity of the BPI-SF have been assessed across a myriad of conditions, such as osteoarthritis, chronic

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obstructive pulmonary disease, cancer, musculoskeletal pain, low back pain, chronic pain, and surgical pain [12,17–21]. The reliability and validity of the BPI-SF have not been assessed in individuals with RCRSP, but this tool has been used as an outcome measure in clinical trials recruiting participants with RCRSP [22–25]. Reliability is the first prerequisite to accurate measurement and validity is the extent to which a test measures what it is intended to measure [26]. There are limited data supporting the BPI-SF reliability and validity in patients with RCRSP, hence, we cannot appropriately interpret data collected using this tool within clinical practice and research contexts [26].

Hence, the aim of this study was to assess the test–retest reliability, construct validity, standard error of measurement (SEM) and minimal detectable change (MDC) of the BPI-SF pain severity and pain interference subscales in individuals with RCRSP. We also assessed the test–retest reliability and measurement error of the stand-alone pain severity and interference questions.

Methods

This test–retest reliability study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the University Ethics Committee (Health) (Ref. H21/117). Written informed consent was obtained from all participants before the study commenced. This study was conducted parallel to a randomised control trial assessing the effects of high-volume mobilisation with movement on shoulder range of motion and pain in individuals with RCRSP [27].

Participants

Participants were recruited from the local community via advertising on social media (i.e., Facebook and Twitter) and the University networks where this study was conducted. Prospective participants were initially screened for eligibility via a web-based questionnaire using REDCap software [28], followed by an in-person confirmative screening assessment. To meet the inclusion criteria, participants were required to be between 18 and 75 years old and demonstrate signs of having RCRSP, as indicated by a painful arc of movement during shoulder abduction, pain on resisted external rotation, pain on resisted abduction, or a positive Jobe's test [29].

Participants were excluded if they presented signs or symptoms suggesting: acute rotator cuff tear due to traumatic event that needs urgent referral, massive rotator cuff tears (defined by gross shoulder muscle weakness in the absence of pain), history of shoulder, or cervical surgery in the past 6 months, corticosteroid injection in the last 6 weeks, other shoulder disorders (i.e., glenohumeral osteoarthritis, history of shoulder subluxation or dislocation, acromioclavicular joint pain, adhesive capsulitis), signs of paresthesia in the upper extremity, systemic inflammation or disease, neurological disease affecting the shoulder, or tumour. We did not use diagnostic imaging to exclude participants. We did not exclude participants based on their ability to speak, read, or understand English.

Procedures

Data collection took place from March to August 2022. Following the in-person confirmative screening assessment, all eligible participants were requested to complete the BPI-SF and Shoulder Pain and Disability Index (SPADI) online form as per the questionnaire's written instructions. The assessor (SW) provided clarification if participants needed help with comprehension. Participants with bilateral shoulder pain were advised to complete the questionnaire based on their most affected side. Current pain medication (within the last 12 hours) and demographic data were also collected, including age, sex, height, weight, ethnicity, hand dominance, painful shoulder side, education level, and duration of symptoms. Participants were invited back to complete the BPI-SF questionnaire a second time at an interval ranging from 2 to 7 days within the same setting. This interval was considered short enough for participants' symptoms to remain stable but long enough to mitigate the effects of recall bias [26]. The same assessor performed both the test and retest. During the retest, the assessor and participants were blind to their original scores. All data were checked for errors before being converted and recorded onto a Microsoft Excel 2019 spreadsheet (Redmond, WA).

Outcome measures

Brief Pain Inventory-Short Form

The BPI-SF pain severity subscale consists of four items that ask participants to rate their worst, least, average pain from the last 24 hours, and their current pain [30]. The pain interference subscale consists of seven items that ask participants to rate how pain has interfered with their daily life during the last 24 hours: general activity, mood, walking ability, work, relationships with others, sleep, and enjoyment of life [30]. For both subscales, participants rate each answer on a scale from 0 (no pain or interference) to 10 (worst pain imaginable or complete interference). Pain severity and interference scores are calculated using the mean score of the individual items in each subscale [30]. For the current study, pain severity, pain interference, and stand-alone pain severity item scores were extracted for analysis.

Shoulder Pain and Disability Index

The SPADI is one of the most shoulder joint-specific patient reported outcome measures and consists of two subscales: pain intensity and functional disability [31]. The pain subscale has five items, and the disability subscale has eight items. Each item ranges from 0 (no pain/no difficulty) to 10 (the worst pain/so difficult required help). The SPADI is a valid and reliable tool for assessing shoulder pain and function and its minimum clinically important difference is 8 points [32].

Sample size

A minimum of 50 participants was recommended for studies assessing reliability and construct validity [33]. This study was conducted parallel to a randomised controlled trial, which required a minimum of 60 participants. Therefore, 60 participants were required for this study.

Statistical analysis

Descriptive statistics were used to describe participant characteristics, BPI-SF and SPADI scores. Means and standard deviations were calculated for continuous variables, whilst frequencies and percentages were calculated for categorical variables. The measurement properties we used for analysis were in accordance with the COSMIN checklist for assessing the methodological quality of studies on measurement properties of health status measurement instruments [34]. Alpha was set at 0.05. All data were analysed using STATA software (StataCorp, College Station, TX) [35].

Test–retest reliability of BPI-SF

Test–retest reliability of the BPI-SF severity subscale, interference subscale, and stand-alone severity items was assessed by calculating

intraclass correlation coefficient (ICC) values using a single measurement, absolute agreement, two-way mixed-effects model (ICC 3,1) [36]. We calculated 95% confidence intervals (CIs) for all ICC values.

Construct validity

To assess the construct validity of BPI-SF, we assessed the correlation between BPI-SF (i.e., BPI-SF pain severity and BPI-SF pain interference) at the initial visit and SPADI pain score, SPADI disability score, or SPADI total score separately. The SPADI has a stringent focus on joint-specific disability [31]. The strength of association was expressed as correlation coefficient (denoted by r) and categorised as small ($0.1 < r < 0.3$), medium ($0.3 < r < 0.5$), and larger ($0.5 < r < 1$) [26].

Standard error of measurement and minimal detectable change

The SEM expresses the variability of scores in the same units as the test. We estimated the SEM for the BPI-SF severity subscale, interference subscale, and stand-alone severity items using the square root of the mean square error term in a repeated-measures analysis of variance (ANOVA) [37,38]. Additionally, the MDC was calculated to demonstrate the change in score that is required to exceed the chance of measurement error, i.e., what score indicates "real change" [39]. The MDC_{95} was calculated with a 95% CI using: $MDC_{95} = SEM \times 1.96 \times \sqrt{2}$ [39,40].

Agreement between measurements

Bland–Altman's plots were computerised for pain severity and interference subscales to visually assess the agreement between test and retest values. The total mean (bias), upper and lower limits of the agreement (LoA) were calculated and plotted, as per the Bland–Altman method [41]. Agreement between measurements was assessed by estimating the magnitude of the mean difference between measurements and the width of the LoA. We assessed the plots visually to identify trends between the magnitude of mean scores and between-test differences.

Results

In total, 158 prospective participants were contacted for online screening. All participants who volunteered to take part in the study could speak, read, and understand English. Of these, 59 were excluded during the web-based preliminary screening and 25 during the in-person confirmative screening assessment. Of the 74 remaining participants, 10 participants were excluded based on not meeting the inclusion criteria for the parallel trial and three were lost to drop out. Data collected from 61 participants were included in the final analysis. Participant characteristics are summarised in Table 1. The mean pain severity and interference subscale scores and mean stand-alone BPI-SF pain severity item scores of test and retest are presented in Table 2.

Table 1. Characteristics of the participants (n = 61).

Characteristics	Descriptive statistics
Age (years)	47.3 (16.0)
Weight (kg)	82.1 (18.5)
Height (cm)	170.2 (10.0)
Body mass index (kg/m^2)	28.4 (6.2)
Sex, *n* (%)	
Male	30 (49)
Duration of shoulder pain (months)[a]	12 (4–36)
Dominant hand, *n* (%)	
Right side	55 (90.2%)
Painful shoulder, *n* (%)	
Right	30 (49.2%)
Education, *n* (%)	
No qualifications	1 (1.6%)
Secondary school	11 (18.0%)
Post-secondary	20 (32.8%)
University degree or above	29 (47.5%)
Employment, *n* (%)	
Employed full-time	37 (60.7%)
Employed part-time	6 (9.8%)
Self-employed	5 (8.2%)
Unemployed	1 (1.6%)
Retired	6 (9.8%)
Student	6 (9.8%)
Ethnicity[b], *n* (%)	
European	56 (91.8%)
Māori	7 (11.5%)
Pacific	1 (1.6%)
Asian	4 (6.6%)
Other	1 (1.6%)
Unknown	1 (1.6%)
Current medication/treatment, *n* (%)	
No treatment	47 (77.0%)
Physiotherapy	2 (3.3%)
Analgesics	7 (11.5%)
Physiotherapy and analgesics	2 (3.3%)
Others	1 (1.6%)
Analgesics and others	2 (3.3%)
SPADI pain subscale	46.16 (18.98)
SPADI disability subscale	28.20 (18.92)
SPADI total	35.11 (17.94)

SPADI: shoulder pain and disability index.
[a]Expressed as median (interquartile range), SD: standard deviation.
[b]Self-identified ethnicity categorised according to the Ministry of Health Ethnicity Data Protocols; a participant can be classified as belonging to multiple ethnic groups; therefore, the total percentage does not equate to 100%.

Table 2. Test–retest reliability, internal consistency, and measurement error of the BPI-SF pain severity and interference subscales.

Domain	Item	Test Mean (SD)	Retest Mean (SD)	ICC (95% CI)	SEM	MDC_{95}
Pain severity	Worst pain	4.9 (2.1)	4.6 (2.2)	0.70 (0.55, 0.81)	1.15	3.19
	Least pain	1.3 (1.4)	1.2 (1.7)	0.64 (0.47, 0.77)	0.93	2.58
	Average pain	3.3 (1.8)	2.7 (1.6)	0.64 (0.43, 0.78)	0.96	2.66
	Current pain	2.5 (1.9)	2.1 (1.7)	0.62 (0.44, 0.75)	1.10	3.05
	Total score	3.0 (1.4)	2.7 (1.5)	0.73 (0.58, 0.83)	0.74	2.05
Pain interference	General activity	3.5 (2.1)	2.5 (1.9)	0.39 (0.14, 0.59)	1.49	4.13
	Mood	2.6 (2.5)	1.4 (1.8)	0.55 (0.23, 0.74)	1.33	3.69
	Walking ability	0.3 (1.1)	0.4 (1.3)	0.68 (0.51, 0.79)	0.69	1.91
	Normal work	3.8 (2.5)	2.4 (2.1)	0.42 (0.13, 0.63)	1.65	4.57
	Relations with others	0.7 (1.4)	0.4 (0.8)	0.46 (0.24, 0.64)	0.84	2.33
	Sleep	4.3 (2.7)	3.2 (2.5)	0.65 (0.41, 0.79)	1.47	4.07
	Enjoyment of life	3.0 (2.6)	1.3 (1.6)	0.46 (0.05, 0.70)	1.40	3.88
	Total score	2.6 (1.6)	1.7 (1.2)	0.53 (0.13, 0.75)	0.85	2.36

SD: standard deviation; ICC: intraclass correlation coefficient; CI: confidence interval; α: alpha coefficient; SEM: standard error of measurement; MDC_{95}: minimal detectable change at the 95% confidence interval.

Table 3. Construct validity between BPI-SF and SPADI.

	BPI Pain intensity	95% CI	BPI Pain interference	95% CI
SPADI pain	0.75	(0.62, 0.85)	0.70	(0.55, 0.81)
SPADI disability	0.61	(0.43, 0.75)	0.70	(0.54, 0.81)
SPADI total	0.71	(0.55, 0.81)	0.74	(0.60, 0.84)

SPADI: shoulder pain and disability index; BPI: Brief Pain Inventory-Short Form; CI: confidence interval.

Test–retest reliability

The pain severity subscale demonstrated moderate reliability (ICC: 0.73, 95% CI: 0.58, 0.83) and pain interference subscales demonstrated poor to moderate reliability (ICC: 0.53, 95% CI: 0.13, 0.75) (Table 2). Of the stand-alone pain severity item, "worst pain" presented the highest reliability (ICC: 0.70, 95% CI: 0.55, 0.81).

Construct validity

The strength of associations between the BPI-SF pain severity and pain interference subscales and SPADI pain, SPADI disability, and SPADI total scores were large ($r \geq 0.61$, Table 3).

Standard error of measurement and minimal detectable change

The SEM and MDC_{95} values of the BPI-SF severity subscale, interference subscale, and stand-alone severity items are presented in Table 2.

Agreement between measurements

Bland–Altman's plots superimposed with mean and LoA values are presented graphically for the pain severity and interference subscales (Figure 1). The mean differences between test and retest scores of the pain severity (0.34) and interference (0.94) subscales are acceptable. The LoA for the severity and interference subscales ranged from −1.72 to 2.39 and −1.41 to 3.28, respectively. Within the interference plot, a linear trend can be observed showing a progressively increasing difference between scores as the mean score increased, suggestive of proportional bias. The pain severity plot shows uniform variability, indicating no systematic bias.

Discussion

To our knowledge, this is the first study to investigate the test–retest reliability and the construct validity of the BPI-SF in individuals with RCRSP. Our study found moderate reliability for the BPI-SF pain severity scale and poor to moderate reliability for the BPI-SF interference subscale. We found the stand-alone pain severity item "worst pain" to present the highest reliability score. The BPI-SF presented good construct validity for assessing pain and disability in individuals with RCRSP. We observed very small differences in scores for both scales between the first and second measurement. That suggests the condition was stable during the period of testing.

The moderate reliability that we observed for the pain severity subscale supports its use in individuals with RCRSP. The 95% CIs associated with our point estimate (0.58, 0.83) indicates a degree of uncertainty in our point estimate. Our findings are similar to those reported by previous researchers [42]. Song et al. [21] reported test–retest reliability of the pain severity and interference of 0.62 and 0.76, respectively, in individuals with low back pain. The lower reliability reported by Song et al. [21] may be due to the fluctuating nature of low back pain compared to RCRSP [43,44]. Other studies have reported the pain severity subscale to be reliable in a variety of populations [12,16,33,45–48]. Our study overcame the limitations highlighted by a systematic review that high-quality studies are needed on test–retest reliability, validity, and measurement error in different musculoskeletal pain populations [48].

Of the stand-alone pain severity items, our findings suggest the "worst pain" item as the most reliable item. Its respective 95% CIs (0.55, 0.81) indicate a degree of uncertainty in our point estimate. These findings are in contrast with the results of other studies [21,42]. Chen et al. [42] found that "least pain" and "average pain" demonstrated better reliability scores in patients with chronic obstructive pulmonary disease; whilst Song et al. [21] reported all four severity items to have poor reliability scores (i.e., ICC = 0.40) in patients with low back pain. Those different findings may be due to different pain patterns associated with different conditions. Symptoms associated with lower back pain are typically volatile [43,44], resulting in variable of reporting of pain. Conversely, RCRSP is often associated with pain during active arm elevation and pain at night-time [7,49,50], and, thus, individuals with RCRSP may experience a stable "worst pain" every 24 hours.

Our findings suggest poor to moderate reliability for the pain interference subscale. Previous studies investigating the pain interference subscale have reported good reliability in individuals with cancer [13,46], osteoarthritis [12], low back pain [21], chronic obstructive pulmonary disease [42], inflammatory bowel disease [45], Parkinson's [33], and chronic pain [47]. The lower reliability observed in our study may be due to low scores and their respective limited variability on the following items: "walking ability" and "relations with others". Homogeneity of scores on those items may have resulted in a lower ICC value in our study [26,51]. The consistently low scores that we observed for the "walking" and "relationships" items are unsurprising considering that those are unlikely to be affected in patients with shoulder pain. By contrast, individuals with low back pain and chronic obstructive pulmonary disease, such as those investigated by previous researchers [21,42], are more likely to experience pain interference with "walking" and "relationships". The fixed items of the BPI-SF interference subscale may render it more appropriate for individuals with systemic conditions or those affecting the lower limb.

Our findings show that scores of >2.05 and >2.36 are required to indicate an actual change (at 95% CI level) on the pain severity and interference subscale scale, respectively. These MDC_{95} values are consistent with those reported by Song et al. [21], who found an MDC of 2.57 for the pain intensity subscale and 2.34 for the pain interference subscale in individuals with low back pain. Our findings also suggest proportional bias in BPI-SF pain interference subscale observed in the Bland–Altman plot. The presence of proportional bias indicates that individuals experiencing greater pain interference may demonstrate greater variability in reporting interference scores. Thus, the MDC_{95} for the interference subscale may not be consistent at different levels of pain interference.

Our study had some limitations. First, the low scores that we observed in the pain interference items may have influenced its reliability. Second, participants within our study were only included if they had RCRSP and responded positively to a mobilisation with

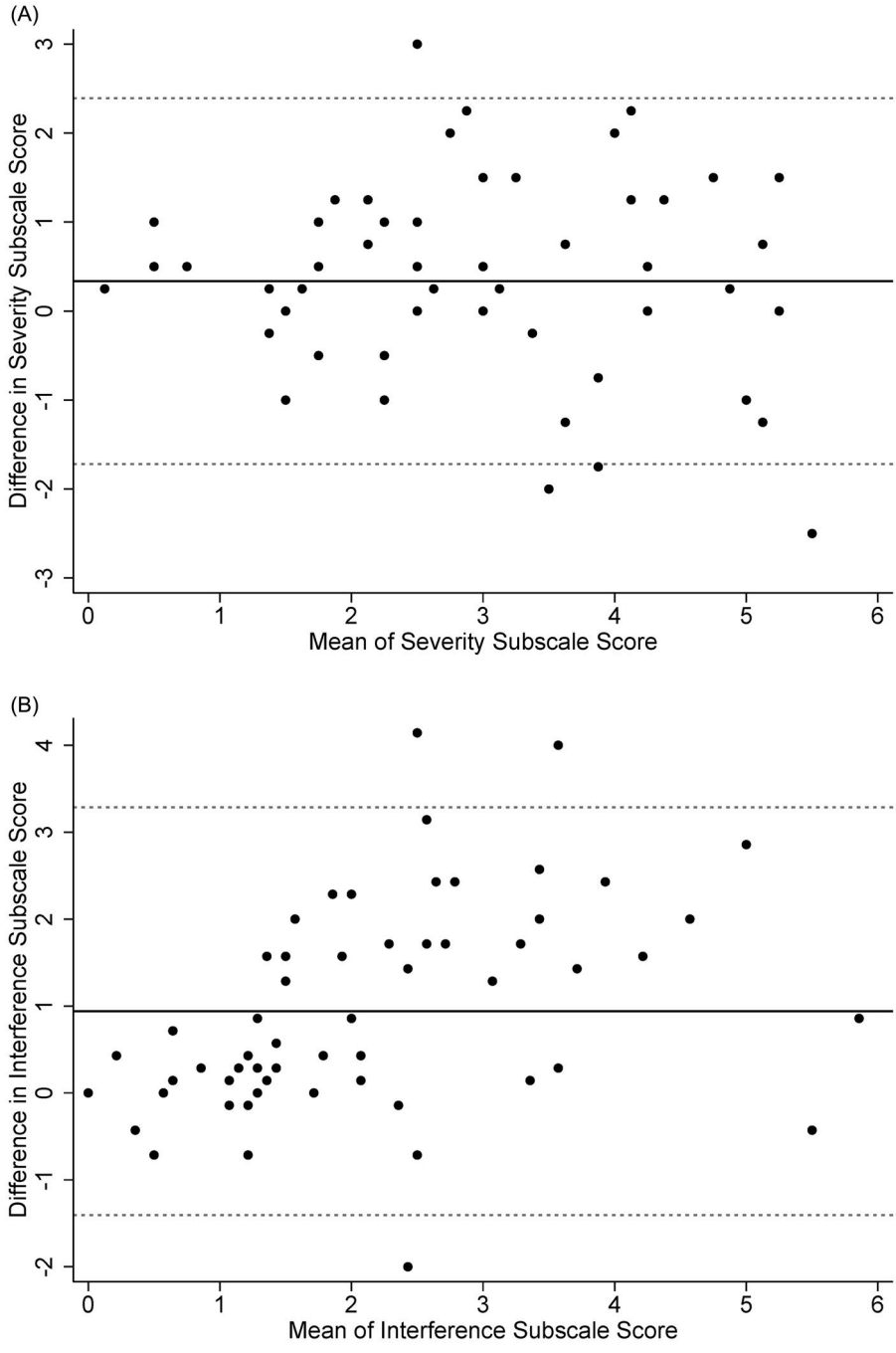

Figure 1. Bland–Altman's plots showing test–retest reliability scores of the BPI-SF severity (A) and interference subscales (B) (n = 61). n: number of participants; BPI-SF: Brief Pain Inventory-Short Form, (A) severity subscale, (B) interference subscale. The central solid line represents the mean difference between test and retest scores. The upper and lower broken lines represent the 95% LoA.

movement technique as part of the main study in which we recruited participants from. Thus, our findings may not be generalisable to individuals with RCRSP who do not respond positively to the same mobilisation with movement technique.

Conclusions

Our findings support the use of the BPI-SF pain severity subscale and stand-alone pain severity item (i.e., "worst pain") in individuals with RCRSP. We found the BPI-SF has good construct validity. The MDC_{95} presented in this paper are relevant for clinicians when assessing changes in BPI-SF scores in patients with RCRSP. We recommend the BPI-SF pain severity subscale and the stand-alone pain severity item (i.e., "worst pain") for monitoring pain intensity and over the last 24 hours for individuals with RCRSP.

Ethical approval

University of Otago Ethics Committee (Health) (Ref. H21/117).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

Data are available if requested.

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