Musculoskeletal
Research Paper

OPEN

PAIN REPORTS

Shoulder pain across more movements is not related to more rotator cuff tendon findings in people with chronic shoulder pain diagnosed with subacromial pain syndrome

Rafael Krasic Alaiti[a,b,*], J.P. Caneiro[c,d], Juliana T. Gasparin[a], Thais Cristina Chaves[e], Eduardo A. Malavolta[f], Mauro E.C. Gracitelli[f], Ann Meulders[g,h], Marcelo Fernandes da Costa[a,i]

Abstract

Introduction: People with chronic shoulder pain commonly report pain during arm movements in daily-life activities. Pain related to movement is commonly viewed as an accurate representation of tissue damage. Thus, when a person reports pain across a variety of movements, this is often understood as indicative of greater damage.

Objectives: We aimed to investigate if movement-related pain that occurs across a wider variety of movements was associated with the number or severity of rotator cuff tendons reported as abnormal on a magnetic resonance imaging (MRI). To answer this question, this study was designed in 3 phases.

Methods: We recruited 130 individuals with chronic shoulder pain diagnosed with subacromial pain syndrome. First, a list of daily functional activities commonly reported as painful by people with chronic shoulder pain was generated from 3 well-established outcome measures with 30 individuals and a measurement tool was developed with data from further 100 individuals, which demonstrated to have acceptable content validity, construct validity, internal consistency, interrater reliability, and structural validity. Multiple linear regression was then used to evaluate the hypotheses of the study. A direct acyclic graph was used to select variables for linear regression modelling.

Results: There was no association between movement-related pain occurrence across movements and the MRI findings.

Conclusion: Our study provides evidence that neither the number of rotator cuff tendons reported as abnormal nor the severity of each tendon imaging finding were associated with pain occurrence across movements and activities commonly perceived as painful by people with chronic shoulder pain.

Keywords: Chronic pain, Shoulder pain, Subacromial pain syndrome, Rotator cuff

1. Introduction

People with chronic shoulder pain commonly report pain during daily activities that require arm movements such as reaching to grasp objects or carry weights, which affects daily life and is often a reason for care seeking. These symptoms are commonly diagnosed as subacromial pain (formerly impingement) syndrome associated with rotator cuff tendinopathy or tear,[56] and clinicians often base their clinical judgements on reports of pain

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

[a] Nucleus of Neuroscience and Behavior and Nucleus of Applied Neuroscience, Universidade de São Paulo, São Paulo, Brazil, [b] Research, Technology, and Data Science Unit, Projeto Superador, São Paulo, Brazil, [c] School of Physiotherapy and Exercise Science, Curtin University, Perth, Australia, [d] Body Logic Physiotherapy, Perth, Australia, [e] Department of Health Sciences and Graduate Program on Rehabilitation and Functional Performance, Ribeirão Preto Medical School, Universidade de São Paulo, Ribeirão Preto, São Paulo, Brazil, [f] Hospital das Clinicas HCFMUSP, Faculdade de Medicina, Universidade de Sao Paulo, Sao Paulo, Brazil, [g] Health Psychology, KU Leuven, Leuven, Belgium, [h] Experimental Health Psychology, Maastricht University, Maastricht, The Netherlands, [i] Department of Experimental Psychology, University of São Paulo, São Paulo, Brazil

*Corresponding author. Address: Departamento de Psicologia Experimental, Instituto de Psicologia, Av. Prof. Mello Moraes 1721, Butantã-São Paulo, SP 05508030, Brasil. Tel.: +5511 3091 1918. E-mail address: alaiti@usp.br (R.K. Alaiti).

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.painrpts.com).

PR9 6 (2021) e980

http://dx.doi.org/10.1097/PR9.0000000000000980

with movement, either looking at patterns of movement and similarities among the painful movements and activities or by doing provocative movements in an attempt to investigate the underlying mechanical causes of pain.[7,21,24,26,42,54]

Although general measures of shoulder pain intensity are poorly correlated with radiological imaging and pathoanatomical diagnosis,[4,12,28,29,36,40,43,55] the association between tissue damage and movement-related pain in subjects with shoulder pain was not properly investigated. To date, the available studies rely on general pain-intensity measures that fail to assess the variability of pain reports during daily life activities of individuals with chronic shoulder pain (ie, the intensity of the pain across different activities), which would provide a more in-depth perception of the pain experience of these individuals. In addition, although the relationship between pain and structural pathology is poor, there is a wide view that more pain or pain in more movements is an accurate measure of more tissue damage (eg, more rotator cuff tendons are damaged)[5,10,11,19] or more severe tissue damage (eg, partial or full-thickness tear).[6]

Therefore, the aim of this study was to verify if movement-related pain that occurs across a wider variety of activities commonly perceived as painful by people with chronic shoulder pain was associated with the number or severity of rotator cuff radiological findings on a magnetic resonance imaging (MRI). Based on the current state of the art, we hypothesized that movement-related pain that occurs across a wider variety of activities would not be associated with the number or severity of rotator cuff MRI findings. To verify these hypotheses, this study was designed in 3 subsequent phases that were aimed to select the activities commonly perceived as painful, develop and evaluate the measurement properties of a measurement tool that assesses the pain occurrence across clinically relevant arm movements, and verify the hypothesis of this study through an analysis of the data collected in phase 2.

2. Materials and methods

2.1. Study design

A cross-sectional study of 3 phases was conducted. In phase 1, 30 people with subacromial pain syndrome were recruited to determine what would be clinically relevant arm movements and activities that were most commonly reported and associated with pain during daily-life activities. Sixteen movements related to reaching, grasping, and hand manipulations with the upper limbs were initially selected from 3 well-established outcome measures, namely, the Constant–Murley,[2] Shoulder Pain and Disability Index,[27] and American Shoulder and Elbow Surgeons Questionnaire.[1] Using a 90% concordance rate of agreement among participants, 10 activities were selected as the most commonly reported and pain provoking activities for people with shoulder pain: unilateral and bilateral reach at 60°, 90°, and 120° of flexion; hand to mouth, head, and back pocket of the pants; and hold 4 kg with the affected limb next to the body. From now on, these activities will be referred to as "clinically relevant arm movements" for people with shoulder pain.

In phase 2, 100 people with chronic shoulder pain diagnosed with subacromial pain syndrome were recruited to develop and evaluate the measurement properties of a measurement tool that assesses the pain occurrence across clinically relevant arm movements selected in the first phase. In phase 3, the hypotheses of this study were verified through an analysis of the data collected in phase 2. The full description of the content validity conducted in the first phase and of the measurement tool development and properties testing conducted in the second phase is presented in the supplementary materials (available at http://links.lww.com/PR9/A142).

2.2. Participants

We included in the study 130 individuals with chronic shoulder pain (ie, pain for at least 3 months) located in the anteroproximal region of the shoulder, diagnosed with subacromial pain syndrome by a combination of clinical examination with positive results for 3 of 5 subacromial pain syndrome tests: (1) Neer, (2) Hawkins–Kennedy, (3) painful arc, (4) pain or weakness resistant to external rotation, and (5) Jobe.[34] Patients in care in the shoulder and elbow Medical Department of the Orthopedic Institute of the Clinical Hospital of São Paulo (Brazil) aged between 40 and 65 year old, sedentary, symptomatic (ie, presenting shoulder pain during movements) with a history of traumatic or insidious onset, were consecutively invited over a period of 3 months to participate in the study.

Exclusion criteria included cognitive impairment identified with the Mini-Mental State Examination, use of medications for pain control in the last 24 hours before the evaluation, neurological diseases, limited shoulder passive range of motion (for external rotation $<30°$ and elevation $<150°$), and previous surgeries in the shoulder and rheumatic diseases.

This study was approved by the Ethics Committee on Human Research of the Psychology Institute [CAAE 49635115.5.0000.5561]. All participants signed the informed consent form.

2.3. Outcome variable

The outcome variable of this study was pain occurrence across clinically relevant arm movements and activities, assessed by the measurement tool developed during the second phase of this study, named the Movement-related Pain Distribution Scale—Shoulder (MRPDS). The main outcome of the MRPDS is a score based on the pain a person experienced during the execution of 10 different activities commonly reported as painful by people with chronic shoulder pain (eg, reaching movements and placing the hand in the back pocket of the pants).

The MRPDS provides an index of the relationship between movement and pain. The index informs on whether pain occurrence is more widespread across activities (eg, pain experienced across most activities of the scale) or whether pain occurrence is more specific to certain movements (eg, pain experienced across fewer activities of the scale). The index also informs on the variability of pain intensity across the activities, whether the pain is of similar intensity across more activities (ie, widespread) or of higher intensity or more varied intensity across fewer activities (ie, specific). Index scores closer to "0" indicate that participants reported pain of similar intensity across more activities. By contrast, higher index scores indicate that participants reported pain of higher intensity or more varied intensity across fewer activities. For a better visualization of the MRPDS and to offer clarity of its interpretation, see **Figure 1**.

The floor score of the MRPDS is 0 (ie, which would be the score for a patient without movement-related pain), but it has no ceiling as several other ratio scales.[46–48] Measurement properties analyses showed acceptable content validity, construct validity, internal consistency, interrater reliability, and structural validity. For more details of the MRPDS, see the supplementary material (available at http://links.lww.com/PR9/A142).

2.4. Independent variables

Questionnaires were used to collect sociodemographic data (age, sex, ethnicity, years of study, and working status) and pain-related variables (number of other musculoskeletal complaints, side of the painful limb, symptoms onset, and duration of symptoms).

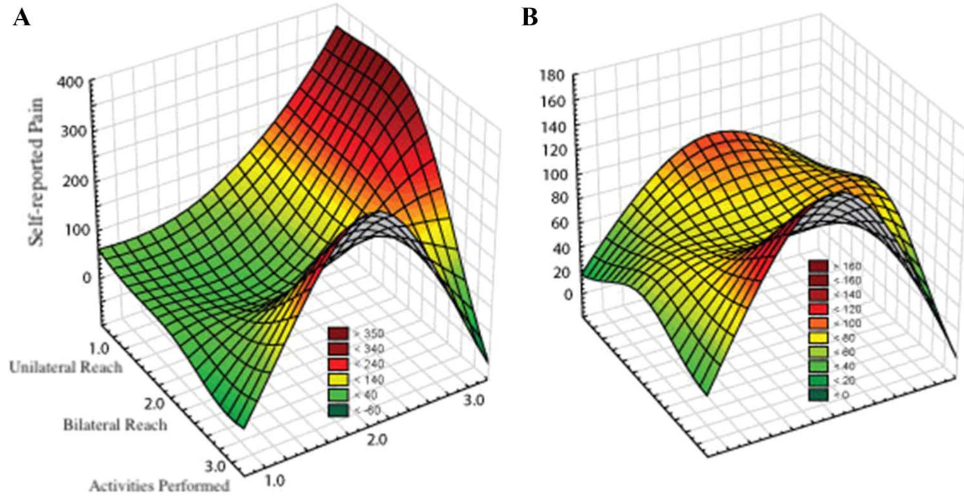

Figure 1. Illustration of the pain distribution across the movements of the scale of 2 subjects of this study. The *z* axis represents the self-reported pain; the first line of the *y* axis represents the unilateral reach movements in 60°, 90°, and 120°, respectively; the second line of the *y* axis represents the bilateral reach movements in 60°, 90°, and 120°, respectively; the third line of the *y* axis represents the movements of drinking water, combing the hair and placing the hand in the back pocket of the pants. In A, it is possible to observe that pain was perceived with high intensities during overhead reaching movements and while combing the hair. In B, pain was perceived across most movements of the scale with similar pain intensities. Although the Movement-related Pain Distribution Scale—Shoulder (MRPDS) of the first subject was 5 and of the second was 0.8, the Visual Analogue Scale of both were the same—6.8 cm.

For the assessment of pain intensity, we used a 10 cm Visual Analogue Scale (VAS) with the left extremity labeled as "no pain" and the right as "worst pain possible."[50] The VAS was administered before the MRPDS, and the patients were asked to rate their level of overall pain in the shoulder based on their symptoms at the time of the evaluation.

Shoulder imaging findings (number of rotator cuff tendons reported as abnormal on a diagnostic scan and the severity of the long head of the biceps, supraspinatus, infraspinatus, and subscapularis tear) were collected and analyzed by 1 radiologist physician with 14 years of experience from the MRI in the medical profile of each participant. The severity of the cuff tendons tears was classified according to a descriptive analysis as normal, tendinopathy, partial thickness tear, and full-thickness tear, whereas the scale used for long head of the biceps pathology was normal, subluxation, dislocation, and full-thickness tear.

The MRI reporting was performed as per usual radiological reporting of the shoulder region. This physician was not involved in the study and was blind for the clinical status of these patients. The time elapsed between the performed MRI and study examination ranged from 4 weeks to 3 months.

2.5. Statistical analysis

According to a sample size calculation using G*POWER, 100 participants were needed to be included for a power of 0.80% and 95% of statistical significance ($\alpha = 0.05$) to detect a 0.12 effect size among the 5 shoulder imaging findings defined as independent variables (ie, number of rotator cuff tendons reported as abnormal, severity of the tendons supraspinatus, infraspinatus, subscapularis, and long head of the biceps imaging finding) and the dependent variable in a multiple linear regression analysis. This sample size is also sufficient for the measurement properties analysis (available in the supplementary file, available at http://links.lww.com/PR9/A142) according to recommendations of the "*Quality criteria for measurement properties of health status questionnaires.*"[52]

Two multiple linear regression analysis were conducted to estimate the association between the shoulder imaging findings, pain intensity, and pain during rest with movement-related pain distribution. The dependent variable was the score of the MRPDS. The 2 regression models were built according to the conceptual framework depicted in **Figure 2**.

To estimate the relationship between MRPDS and the other variables, a parameter estimate (β) and confidence intervals (95% CIs) were calculated using R Studio v1.1.414 (RStudio Team, 2018). First, univariate linear regressions were conducted between each of the independent variables and the MRPDS. The collinearity among variables was then assessed, but as no strong correlation between variables was found, all the hypothesized variables were included in the final models. When subjects present with bilateral shoulder pain, the data from the dominant side were used in the regression models.

The adjusted coefficient of determination (R^2), a proportional measure indicating the amount of variation in outcome explained by the models, is presented. Sensitivity analysis was conducted to verify the effect of other measured possible confounding variables (eg, sex and age). The homoscedasticity of the final models and models diagnosis (ie, outliers, aberrant, and leverage points) were verified through visual inspection.

3. Results

The participants' characteristics are presented in **Table 1**, and the β weights of the univariate and multiple regression analyses are presented in **Table 2**. A negative β refers to smaller MRPDS scores (more widespread movement-related pain occurrence across activities), and a positive β refers to higher MRPDS scores (more specific movement-related pain occurrence across activities).

During the univariate regression analyses, pain intensity ($\beta = -0.2$, $P = 0.001$; 95% CI -0.31 to -0.05) and pain during rest ($\beta = -1.53$, $P < 0.001$; 95% CI -2.37 to -0.7) were associated with MRPDS. None of the independent variables were associated with the MRPDS in model 1 (adjusted $R^2 = 0.01$), whereas pain during rest ($\beta = -1.68$, $P < 0.001$; 95% CI -2.6 to -0.7) was associated with MRPDS in model 2 (adjusted $R^2 = 0.13$).

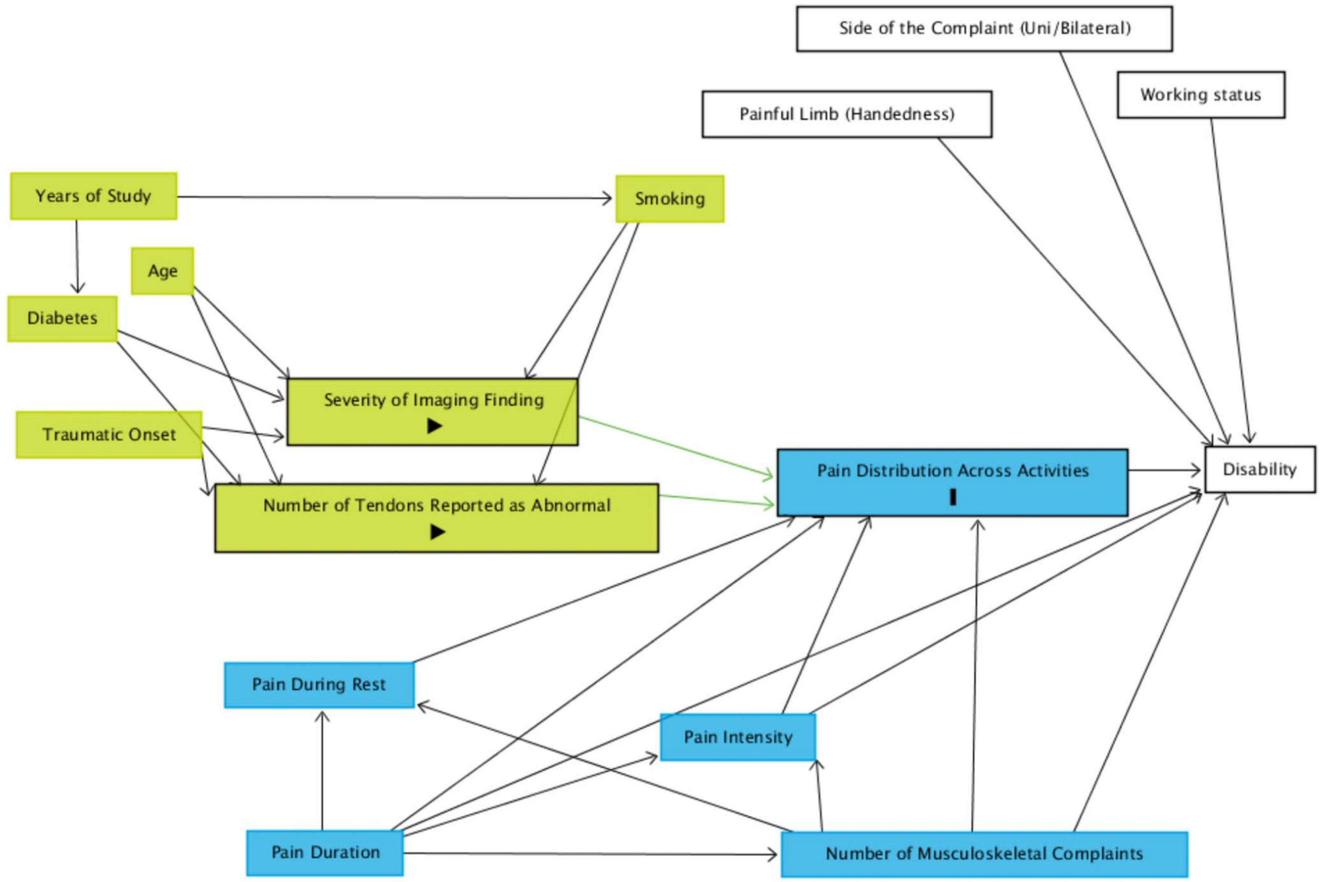

Figure 2. Directed acyclic graph (DAG) describing the conceptual framework used to construct the multiple linear regression models to verify the hypothesis of this study.[4,12,38,39,41,53,55] The Movement-related Pain Distribution Scale—Shoulder (MRPDS) was used as a dependent variable. The independent variables of the first model were (1) number of tendons reported as abnormal and severity of the (2) supraspinatus, (3) infraspinatus, (4) subscapularis, and (5) long head of the biceps imaging finding. In the second model, the variables (6) pain during rest and (7) pain intensity were added to the variables of the previous model as independent variables, and the model was further adjusted by pain duration and number of musculoskeletal complaints.

Sensitivity analysis suggested that model 2 was better adjusted than the model 1 ($F_{1,5} = 3.75$, $P < 0.001$) and that adjusting both models for other possible confounding variables was not significant. We further tested the convergent fit indices of the second multiple regression model with Bayesian Information Criterion and Akaike Information Criterion, which suggested to select just the variables pain intensity, pain during rest, and number of tendons reported as abnormal. We created another multiple regression analysis with these variables as independent variables. This analysis suggested that pain during rest ($\beta = -1.4$, $P < 0.001$; 95% CI -2.2 to -0.59) was associated with MRPDS (adjusted $R^2 = 0.17$), and no significant difference was found with the second multiple regression model ($F_{1,14} = 0.66$, $P = 0.79$).

During model diagnosis, no aberrant and leverage points were found; the residuals of both models were normally distributed, and the error variance was homoscedastic.

4. Discussion

In this study, we investigated if movement-related pain occurrence across clinically relevant arm movements for people with chronic shoulder pain diagnosed by an orthopedic surgeon as subacromial pain syndrome was associated with the number of rotator cuff tendons reported as abnormal or the severity of these abnormal findings on a MRI. Based on current literature, we hypothesized that movement-related pain that is reported across a wider variety of activities would not be associated with the number or severity of rotator cuff MRI findings.

Our hypothesis was confirmed. Neither the number of rotator cuff tendons reported as abnormal nor the severity of each tendon finding was associated with the pain occurrence across clinically relevant arm movements and activities. These findings are consistent with other studies that investigated the association between general measures of pain intensity, disability, and the number and severity of imaging findings in individuals with chronic shoulder pain diagnosed with subacromial pain syndrome, which demonstrated that neither the presence of imaging findings nor the severity of the findings were associated with general measures of pain intensity or disability.[4,12,35,55]

Although some of these findings may fall within normal age-related changes, in Brazil, similar to other parts of the world, radiological reporting does not often include that information. Instead, radiological reports often simply described anatomy that differs from what is considered normal and people with shoulder pain are often diagnosed and treated based on these radiological labels.

Despite both pain during rest and pain intensity variables being associated with movement-related pain occurrence across activities during the univariate linear regression models, only pain during rest ($\beta = -1.68$, $P < 0.001$; 95% CI -2.6 to -0.7) remained significant during multiple regression analysis.

Table 1

Summary characteristics of phase 2 participants (n = 100).

	Mean (SD)	N (%)
Age (y)	55 (8.56)	
Sex (female)		74
Ethnicity		64
White		64
Black		30
Others		6
Duration of symptoms (mo)	76 (24)	
Total years of study (y)	6.48 (4.2)	
Working status		
Employed		35
Unemployed or retired		44
Sick leave		21
Spontaneous pain at rest (yes)		35
Pain intensity (VAS)	4 (2.3)	
MRPDS score	3.46 (2.12)	
Painful limb (dominant)		59
Side of the complaint (bilateral)		46
No. of ME complaints (2 or more)		50
No. of rotator cuff tendons reported as abnormal in MRI		
0 or 1		4
2		25
3		27
4		44
Severity of the imaging finding reported in MRI		
Supraspinatus		
None		13
Tendinopathy		12
Partial-thickness tear		21
Full-thickness tear		54
Infraspinatus		
None		45
Tendinopathy		16
Partial-thickness tear		16
Full-thickness tear		23
Subscapularis		
None		31
Tendinopathy		17
Partial-thickness tear		38
Full-thickness tear		14
Long Head of the Biceps		
Reduced		45
Subluxation		9
Dislocation		8
Full-thickness tear		38

Duration of symptoms ranged from 5 months to 10 years.
ME, musculoskeletal; MRPDS, Movement-related Pain Distribution Scale—Shoulder; MRI, magnetic resonance imaging; N, number; VAS, Visual Analogue Scale.

This means that individuals with a more widespread pain distribution across activities (ie, subjects that reported pain across more activities) were more prone to present pain during rest, regardless of the other variables in the model. Therefore, clinicians should be aware that subjects with pain during rest may be more prone to report pain during more clinically relevant arm movements. However, this does not imply causation and might happen by other factors that may be common causes for pain during rest and a more widespread pain occurrence through movements.

In summary, the findings of this study demonstrate that movement-related pain that occurs across a wider variety of arm movements in people with chronic shoulder pain diagnosed with subacromial pain syndrome was not associated with the number of rotator cuff tendons reported as abnormal or with the severity of each tendon finding, but it was positively associated with pain during rest.

4.1. Implications

The present findings have both clinical and theoretical implications. From a clinical perspective, the results of this analysis provide a deeper understanding about between-individual and within-individual differences in movement-related shoulder pain presentation. The number or severity of rotator cuff radiological findings on an MRI was not associated with pain occurrence across clinically relevant arm movements for people with chronic shoulder pain.

This is in contrast with the common view that movement-related pain is an accurate representation of tissue damage.[6,10,11,19] This view is not supported by current evidence[4,12,55] and can in fact instill the belief that the body is damaged and needs protection, leading to fear, avoidance, and escalation of care-seeking.[49] Therefore, the results of this study provide further support to recent calls for clinicians to move away from the reductionist pathoanatomical model to explain chronic shoulder pain, towards a multidimensional model.[25] Nevertheless, pathoanatomical factors should not be discarded completely for all shoulder patients, because other complaints (eg, shoulder instability) may be associated with such factors.

On the theoretical level, our findings, that a more widespread pain occurrence across movements is not associated with tissue damage, but with pain and disability (as outlined by our main analysis and during the construct validity presented in the supplementary file, available at http://links.lww.com/PR9/A142), provide insight into a person's protective response to a threat. These findings share similarities with previous research on other protective responses such as pain-related fear and fear of movement-related pain, in which a less precise and more contextual pain has been shown to lead to unbridled fear generalization to safe stimuli and contexts fostering sustained anxiety and excessive avoidance behavior, initiating a pathway toward disability in people with chronic pain.[14,23,30,57,58]

Learning theory can also be used to shed light on the individual variability in movement-related pain in people with chronic pain.[15,30,57] Processes of nonassociative learning in the form of peripheral or central sensitization were previously identified in people with chronic shoulder pain[3,8,37,44] and could be related to movement-related pain occurrence. The association between the presence of pain during rest with a more widespread pain occurrence across activities found in our study could be a sign of peripheral sensitization, because spontaneous pain is commonly viewed as a sign of a nociceptive mechanism of pain,[45] or central sensitization if accompanied by a diffuse and disproportionate painful experience.[37] This could be adequately investigated in future studies.

Besides that, learned expectancy,[51] threat discrimination,[18] fear generalization, and category-based or conceptual fear conditioning[9,13,20,22,30] have previously been associated with the contextual modulation of pain experience in healthy subjects and seems to be disturbed in subjects with other chronic pain conditions.[16,18,31–33] Future studies should consider the role of these learning processes on explaining movement-related pain and its occurrence through movements in people with chronic shoulder pain.

4.2. Limitations

The main limitation of this study is its cross-sectional design. Therefore, it is not possible to infer causation between the

Table 2

Multiple linear regression for Movement-related Pain Distribution: n = 100, adjusted R^2 = 0.13.

	Univariate linear regressions	Multiple linear regressions			
	Parameter estimate	Model 1	95% CI	Model 2	95% CI
No. of abnormal tendons					
2	−0.46 (P = 0.45)	−9.2 (P = 0.14)	−21 to 3.35	−4.93 (P = 0.45)	−8.13 to 18
3	0.32 (P = 0.57)	−0.2 (P = 0.77)	−1.65 to 1.24	0.08 (P = 0.9)	−1.29 to 1.46
4	0.95 (P = 0.1)	0.83 (P = 0.1)	−0.15 to 1.82	0.59 (P = 0.21)	−0.35 to 0.54
Supraspinatus					
Tendinopathy	−0.41 (P = 0.38)	−2.39 (P = 0.23)	−1.6 to 6.3	−1.9 (P = 0.36)	−6.12 to 2.26
Partial thickness tear	0.56 (P = 0.56)	−1.61 (P = 0.3)	−4.7 to 1.49	1.46 (P = 0.36)	−1.68 to 4.6
Full-thickness tear	−0.41 (P = 0.44)	−0.43 (P = 0.6)	−1.21 to 2.07	−0.49 (P = 0.57)	−2.22 to 1.24
Infraspinatus					
Tendinopathy	−0.25 (P = 0.52)	2.72 (P = 0.16)	−1.1 to 6.55	−1.73 (P = 0.39)	−5.76 to 2.28
Partial thickness tear	−0.59 (P = 0.2)	−3.3 (P = 0.1)	−6.7 to 0.15	0.1 (P = 0.93)	−2.67 to 2.88
Full-thickness tear	−0.02 (P = 0.96)	1.22 (P = 0.24)	−0.87 to 3.3	0.4 (P = 0.8)	−2.3 to 1.8
Subscapularis					
Tendinopathy	0.04 (P = 0.93)	2.47 (P = 0.17)	−1.1 to 6.06	−1.85 (P = 0.37)	−6 to 2.3
Partial thickness tear	0.55 (P = 0.23)	−1.47 (P = 0.27)	−4.1 to 4.18	1.9 (P = 0.37)	−1.23 to 5.19
Full-thickness tear	−0.1 (P = 0.82)	−0.8 (P = 0.88)	−1.8 to 3	−1.43 (P = 0.17)	−3.5 to 0.63
Long head of the biceps					
Subluxation	0.52 (P = 0.39)	0.64 (P = 0.34)	−0.71 to 2	0.64 (P = 0.35)	−0.72 to 2
Dislocation	−0.18 (P = 0.87)	−0.25 (P = 0.83)	−2.7 to 2.1	−0.91 (P = 0.46)	−3.3 to 1.54
Full-thickness tear	−1.28 (P = 0.39)	−0.83 (P = 0.58)	−3.8 to 2.2	−0.97 (P = 0.54)	−4.1 to 2.19
Pain intensity	−0.2 (P = 0.001)**	—	—	−0.04 (P = 0.57)	−0.19 to 0.1
Pain during rest	−1.53 (P < 0.001)***	—	—	−1.68 (P < 0.001)***	−2.6 to −0.7
No. of musculoskeletal complaints					
1	−0.67 (P = 0.12)	—	—	−0.41 (P = 0.39)	−1.3 to 0.55
>2 or more	−0.01 (P = 0.96)	—	—	−0.28 (P = 0.44)	−1.03 to 0.45
Pain duration	—	—	—	0.001 (P = 0.83)	−0.05 to 0.05
R^2		0.01	—	0.13	—

The Movement-related Pain Distribution Scale—Shoulder (MRPDS) was used as a dependent variable in models 1 and 2. The independent variables of the first model were (1) number of tendons reported as abnormal and severity of the (2) supraspinatus, (3) infraspinatus, (4) subscapularis, and (5) long head of the biceps imaging finding. In the second model, the variables (6) pain during rest and (7) pain intensity were added to the variables of the previous model as independent variables, and the model was further adjusted by pain duration and number of musculoskeletal complaints *P < 0.05; **P < 0.01; ***P < 0.001.

associations found. Besides that, the approach to determine what would be the activities that were most commonly reported and associated with pain during daily life activities might not be representative of the role population of people with chronic shoulder pain, as it did not follow a Delphi design.

Other activities not assessed by the questionnaires used at phase 1 to select the activities for the MRPDS might also be clinically important for people with shoulder pain. The only strength assessment in MRPDS, for example, was conducted with the arm to the side of the body. Since people with shoulder pain may report pain when tendons are loaded in other positions (eg, overhead), this may be a potential limitation of the study.

Moreover, although several clinical factors have been evaluated in this study, they do not represent all the variables that can influence the clinical outcome. Therefore, we acknowledge that other variables not described in the directed acyclic graph may be important to understand which factors are associated with pain occurrence across movements in people with subacromial pain syndrome.

Besides that, the results in this study are applicable to patients with chronic shoulder pain diagnosed with subacromial pain syndrome (mean duration of symptoms of 6 years), with very few years of study and with the majority being females (74%), not working (65%) and with 50% having 2 or more musculoskeletal complaints. Therefore, we cannot from this study rule out that the association between pain and structural abnormalities could be stronger in a different cohort (eg, with shorter symptom duration and younger age).

Finally, the MPRDS was developed for use in a population of patients with subacromial impingement and may not be immediately applicable to shoulder pain from other pathologies.

5. Conclusion

Our study provides evidence that neither the number of rotator cuff tendons nor the severity of each tendon reported as abnormal on a MRI was associated with pain occurrence across movements and activities commonly perceived as painful by people with chronic shoulder pain diagnosed with subacromial pain syndrome. This is in contrast with the common view that movement-related pain is as an accurate representation of tissue damage and, therefore, that more pain or pain in more movements is an accurate measure of more tissue damage or more severe tissue damage. These findings provide insight to future research to further investigate which factors are associated with pain occurrence across movements in people with subacromial pain syndrome.

Disclosures

The authors have no conflict of interest to declare.

Acknowledgements

This work was supported by the scholarship 168816 from the CNPq and FAPESP #04049-4. The author M. Fernandes da Costa is a CNPq research fellow. There are no conflicts of

interest. All authors contributed and approved the final version submitted.

Appendix A. Supplemental digital content

Supplemental digital content associated with this article can be found online at http://links.lww.com/PR9/A142.

Article history:
Received 29 July 2021
Received in revised form 21 October 2021
Accepted 26 October 2021

References

[1] Angst F, Schwyzer HK, Aeschlimann A, Simmen BR, Goldhahn J. Measures of adult shoulder function: disabilities of the arm, shoulder, and hand questionnaire (DASH) and its short version (QuickDASH), shoulder pain and disability index (SPADI), American shoulder and elbow surgeons (ASES) society standardized shoulder assessment form, constant (Murley) score (CS), simple shoulder test (SST), Oxford shoulder score (OSS), shoulder disability questionnaire (SDQ), and Western Ontario shoulder instability index (WOSI). Arthritis Care Res (Hoboken) 2011; 63(suppl 11):S174–88.
[2] Barreto RP, Barbosa ML, Balbinotti MA, Mothes FC, da Rosa LH, Silva MF. The Brazilian version of the Constant-Murley Score (CMS-BR): convergent and construct validity, internal consistency, and unidimensionality. Rev Bras Ortop 2016;51:515–20.
[3] Borstad J, Woeste C. The role of sensitization in musculoskeletal shoulder pain. Braz J Phys Ther 2015;19:251–7.
[4] Brophy RH, Dunn WR, Kuhn JE. Shoulder activity level is not associated with the severity of symptomatic, atraumatic rotator cuff tears in patients electing nonoperative treatment. Am J Sports Med 2014;42:1150–4.
[5] Bunzli S, Smith A, Schütze R, Lin I, O'Sullivan P. Making sense of low back pain and pain-related fear. J Orthop Sports Phys Ther 2017;47:628–36.
[6] Caneiro JP, Bunzli S, O'Sullivan P. Beliefs about the body and pain: the critical role in musculoskeletal pain management. Braz J Phys Ther 2021; 25:17–29.
[7] Cools AM, Struyf F, De Mey K, Maenhout A, Castelein B, Cagnie B. Rehabilitation of scapular dyskinesis: from the office worker to the elite overhead athlete. Br J Sports Med 2014;48:692–7.
[8] Coronado RA, Simon CB, Valencia C, George SZ. Experimental pain responses support peripheral and central sensitization in patients with unilateral shoulder pain. Clin J Pain 2014;30:143–51.
[9] Crombez G, Eccleston C, Van Damme S, Vlaeyen JW, Karoly P. Fear-avoidance model of chronic pain: the next generation. Clin J Pain 2012; 28:475–83.
[10] Darlow B. Beliefs about back pain: the confluence of client, clinician and community. Int J Osteopathic Med 2016;20:53–61.
[11] Darlow B, Dean S, Perry M, Mathieson F, Baxter GD, Dowell A. Easy to harm, hard to heal: patient views about the back. Spine (Phila Pa 1976) 2015;40:842–50.
[12] Dunn WR, Kuhn JE, Sanders R, An Q, Baumgarten KM, Bishop JY, Brophy RH, Carey JL, Holloway GB, Jones GL, Ma CB, Marx RG, McCarty EC, Poddar SK, Smith MV, Spencer EE, Vidal AF, Wolf BR, Wright RW. Symptoms of pain do not correlate with rotator cuff tear severity: a cross-sectional study of 393 patients with a symptomatic atraumatic full-thickness rotator cuff tear. J Bone Joint Surg Am 2014;96:793–800.
[13] Dunsmoor JE, Murphy GL. Categories, concepts, and conditioning: how humans generalize fear. Trends Cogn Sci 2015;19:73–7.
[14] Gheldof EL, Crombez G, Van den Bussche E, Vinck J, Van Nieuwenhuyse A, Moens G, Mairiaux P, Vlaeyen JW. Pain-related fear predicts disability, but not pain severity: a path analytic approach of the fear-avoidance model. Eur J Pain 2010;14:870.e1–9.
[15] Goubert L, Vlaeyen JW, Crombez G, Craig KD. Learning about pain from others: an observational learning account. J Pain 2011;12:167–74.
[16] Harvie DS, Broecker M, Smith RT, Meulders A, Madden VJ, Moseley GL. Bogus visual feedback alters onset of movement-evoked pain in people with neck pain. Psychol Sci 2015;26:385–92.
[17] Harvie DS, Moseley GL, Hillier SL, Meulders A. Classical conditioning differences associated with chronic pain: a systematic review. J Pain 2017;18:889–98.
[18] Harvie DS, Weermeijer JD, Olthof NA, Meulders A. Learning to predict pain: differences in people with persistent neck pain and pain-free controls. PeerJ 2020;8:e9345.
[19] de Oliveira BIR, Smith AJ, O'Sullivan PPB, Haebich S, Fick D, Khan R, Bunzli S. 'My hip is damaged': a qualitative investigation of people seeking care for persistent hip pain. Br J Sports Med 2020;54: 858–65.
[20] Kaczkurkin AN, Burton PC, Chazin SM, Manbeck AB, Espensen-Sturges T, Cooper SE, Sponheim SR, Lissek S. Neural substrates of overgeneralized conditioned fear in PTSD. Am J Psychiatry 2017;174: 125–34.
[21] Kent P, Keating J. Do primary-care clinicians think that nonspecific low back pain is one condition? Spine (Phila Pa 1976) 2004;29:1022–31.
[22] LeDoux JE, Moscarello J, Sears R, Campese V. The birth, death and resurrection of avoidance: a reconceptualization of a troubled paradigm. Mol Psychiatry 2017;22:24–36.
[23] Lee H, Hubscher M, Moseley GL, Kamper SJ, Traeger AC, Mansell G, McAuley JH. How does pain lead to disability? A systematic review and meta-analysis of mediation studies in people with back and neck pain. PAIN 2015;156:988–97.
[24] Lewis JS, Green A, Wright C. Subacromial impingement syndrome: the role of posture and muscle imbalance. J Shoulder Elbow Surg 2005;14: 385–92.
[25] Lin I, Wiles L, Waller R, Goucke R, Nagree Y, Gibberd M, Straker L, Maher CG, O'Sullivan PPB. What does best practice care for musculoskeletal pain look like? Eleven consistent recommendations from high-quality clinical practice guidelines: systematic review. Br J Sports Med 2020;54: 79–86.
[26] Ludewig PM, Reynolds JF. The association of scapular kinematics and glenohumeral joint pathologies. J Orthop Sports Phys Ther 2009;39: 90–104.
[27] Martins J, Napoles BV, Hoffman CB, Oliveira AS. The Brazilian version of shoulder pain and disability index: translation, cultural adaptation and reliability. Rev Bras Fisioter 2010;14:527–36.
[28] McClure PW, Bialker J, Neff N, Williams G, Karduna A. Shoulder function and 3-dimensional kinematics in people with shoulder impingement syndrome before and after a 6-week exercise program. Phys Ther 2004; 84:832–48.
[29] McQuade KJ, Borstad J, de Oliveira AS. Critical and theoretical perspective on scapular stabilization: what does it really mean, and are we on the right track? Phys Ther 2016;96:1162–9.
[30] Meulders A. Fear in the context of pain: lessons learned from 100 years of fear conditioning research. Behav Res Ther 2020;131:103635.
[31] Meulders A, Boddez Y, Blanco F, Van Den Houte M, Vlaeyen JWS. Reduced selective learning in patients with fibromyalgia vs healthy controls. PAIN 2018;159:1268–76.
[32] Meulders A, Harvie DS, Bowering JK, Caragianis S, Vlaeyen JW, Moseley GL. Contingency learning deficits and generalization in chronic unilateral hand pain patients. J Pain 2014;15:1046–56.
[33] Meulders A, Jans A, Vlaeyen JW. Differences in pain-related fear acquisition and generalization: an experimental study comparing patients with fibromyalgia and healthy controls. PAIN 2015;156:108–22.
[34] Michener LA, Walsworth MK, Doukas WC, Murphy KP. Reliability and diagnostic accuracy of 5 physical examination tests and combination of tests for subacromial impingement. Arch Phys Med Rehabil 2009;90: 1898–903.
[35] Minagawa H, Yamamoto N, Abe H, Fukuda M, Seki N, Kikuchi K, Kijima H, Itoi E. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: from mass-screening in one village. J Orthop 2013;10:8–12.
[36] Navarro-Ledesma S, Struyf F, Labajos-Manzanares MT, Fernandez-Sanchez M, Morales-Asencio JM, Luque-Suarez A. Does the acromiohumeral distance matter in chronic rotator cuff related shoulder pain? Musculoskelet Sci Pract 2017;29:38–42.
[37] Noten S, Struyf F, Lluch E, D'Hoore M, Van Looveren E, Meeus M. Central pain processing in patients with shoulder pain: a review of the literature. Pain Pract 2017;17:267–80.
[38] Plinsinga ML, Brink MS, Vicenzino B, van Wilgen CP. Evidence of nervous system sensitization in commonly presenting and persistent painful tendinopathies: a systematic review. J Orthop Sports Phys Ther 2015;45: 864–75.
[39] Raman J, Walton D, MacDermid JC, Athwal GS. Predictors of outcomes after rotator cuff repair-A meta-analysis. J Hand Ther 2017; 30:276–92.
[40] Ratcliffe E, Pickering S, McLean S, Lewis J. Is there a relationship between subacromial impingement syndrome and scapular orientation? A systematic review. Br J Sports Med 2014;48:1251–6.
[41] Saccomanno MF, Sircana G, Cazzato G, Donati F, Randelli P, Milano G. Prognostic factors influencing the outcome of rotator cuff repair: a systematic review. Knee Surg Sports Traumatol Arthrosc 2016;24: 3809–19.

[42] Sahrmann S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. Braz J Phys Ther 2017;21: 391–9.
[43] Salamh P, Lewis J. It is time to put 'special tests' for rotator cuff related shoulder pain out to pasture. J Orthopaedic Sports Phys Ther 2020;50: 222–5.
[44] Sanchis MN, Lluch E, Nijs J, Struyf F, Kangasperko M. The role of central sensitization in shoulder pain: a systematic literature review. Semin Arthritis Rheum 2015;44:710–6.
[45] Smart KM, Blake C, Staines A, Doody C. The discriminative validity of "nociceptive," "peripheral neuropathic," and "central sensitization" as mechanisms-based classifications of musculoskeletal pain. Clin J Pain 2011;27:655–63.
[46] Stevens SS. Measurement and man. Science 1958;127:383–9.
[47] Stevens SS. Problems and methods of psychophysics. Psychol Bull 1958;55:177–96.
[48] Stevens SS. Concerning the psychophysical power law. Q J Exp Psychol 1964;16:383–5.
[49] Stewart M, Loftus S. Sticks and stones: the impact of language in musculoskeletal rehabilitation. J Orthop Sports Phys Ther 2018;48:519–22.
[50] Tashjian RZ, Deloach J, Porucznik CA, Powell AP. Minimal clinically important differences (MCID) and patient acceptable symptomatic state (PASS) for visual analog scales (VAS) measuring pain in patients treated for rotator cuff disease. J Shoulder Elbow Surg 2009;18:927–32.
[51] Taylor VA, Chang L, Rainville P, Roy M. Learned expectations and uncertainty facilitate pain during classical conditioning. PAIN 2017;158: 1528–37.
[52] Terwee CB, Bot SD, de Boer MR, van der Windt DA, Knol DL, Dekker J, Bouter LM, de Vet HC. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol 2007;60:34–42.
[53] Thorpe AM, O'Sullivan PB, Mitchell T, Hurworth M, Spencer J, Booth G, Goebel S, Khoo P, Tay A, Smith A. Are psychologic factors associated with shoulder scores after rotator cuff surgery? Clin Orthop Relat Res 2018;476:2062–73.
[54] Timmons MK, Lopes-Albers AD, Borgsmiller L, Zirker C, Ericksen J, Michener LA. Differences in scapular orientation, subacromial space and shoulder pain between the full can and empty can tests. Clin Biomech (Bristol, Avon) 2013;28:395–401.
[55] Unruh KP, Unruh KP, Kuhn JE, Sanders R, An Q, Baumgarten KM, Bishop JY, Brophy RH, Carey JL, Holloway BG, Jones GL, Ma BC, Marx RG, McCarty EC, Poddar SK, Smith MV, Spencer EE, Vidal AF, Wolf BR, Wright RW, Dunn WR. The duration of symptoms does not correlate with rotator cuff tear severity or other patient-related features: a cross-sectional study of patients with atraumatic, full-thickness rotator cuff tears. J Shoulder Elbow Surg 2014;23:1052–8.
[56] van der Windt DA, Koes BW, de Jong BA, Bouter LM. Shoulder disorders in general practice: incidence, patient characteristics, and management. Ann Rheum Dis 1995;54:959–64.
[57] Vlaeyen JW. Learning to predict and control harmful events: chronic pain and conditioning. PAIN 2015;156(suppl 1):S86–93.
[58] Vlaeyen JW, Crombez G, Linton SJ. The fear-avoidance model of pain. PAIN 2016;157:1588–9.