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Exercise for rotator cuff-related shoulder pain is ubiquitous: 'how and why' is it beneficial?

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Exercise for rotator cuff-related shoulder pain is ubiquitous: ‘How and why’ is it beneficial?

Jared Powell

Submitted in total fulfilment of the requirements of the degree of
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ABSTRACT

Rotator cuff-related shoulder pain (RCRSP) is the most common musculoskeletal condition of the shoulder joint and can cause profound disruption to activities of daily living and participation in valued activity. The negative sequelae of RCRSP continues to fuel the ongoing pursuit of effective treatments to help manage pain and disability. Exercise therapy is the most recommended treatment for RCRSP, because it out-performs no treatment and usual care comparators and is generally well received by patients. However, while exercise therapy for RCRSP has a rich literature investigating its effectiveness, much less research has explored how and why it causes an effect. In other words, the causal mechanisms underpinning a reduction in shoulder pain or an improvement in shoulder function through engaging with an exercise program for individuals with RCRSP is currently obtruse. At the commencement of this research program this was a substantial knowledge gap. The studies in the thesis are an attempt to contribute to the diminution of this knowledge gap and provide a foundation for future research.

Chapters 1&2 introduce RCRSP and its history, briefly describes common treatment options for RCRSP and outlines the importance of causal explanation in health science. The philosophical foundation that guides this research program is introduced and explained, as well as the research gaps, questions, and aims this thesis intends to explore.

Chapter 3 is an editorial that pithily summarises the current evidence-base concerning possible mechanisms of clinical improvement through engaging with a resistance exercise program for RCRSP. The editorial of Chapter 3 supports a more comprehensive analysis of causal mechanisms in the following chapters and functions as a philosophical entrée for the remainder of the thesis. It outlines the uncertainty surrounding how and why exercise may help an individual with RCRSP, and specifically challenges the prevailing view that ‘getting stronger’ or ‘optimising scapular position or motion’ is what’s responsible for a positive clinical outcome with exercise therapy.

Chapters 4-6 explore the views of clinical researchers, clinicians, and patients about how and why they believe exercise to be beneficial for RCRSP. The outcomes of these chapters and their corresponding studies reveal commonalities and discrepancies among the different stakeholders. The major through-line connecting the stakeholders is that exercise was hypothesised to work predominately via neuromuscular mechanisms (changes to muscle strength and motor control for example). Differences existed at the level of importance attached to psychosocial mechanisms, with

patients and clinicians more likely to invoke these mechanisms to explain the effect of exercise compared to clinical researchers. Chapter 6 is a qualitative study that identified a positive experience with exercise therapy is context dependent, most prominently on the relationship between clinician and patient and the perceived individualisation of the exercise program.

Chapter 7 critically discusses the current uncertainty and limitations of the evidence-base regarding exercise therapy for RCRSP, the problems this may present for clinicians prescribing exercise in clinical practice and offers considerations and strategies to help navigate identified uncertainty. Chapter 8 explores whether the best way to judge the efficacy and effectiveness of exercise therapy for RCRSP is strictly through randomised controlled trials and their associated effect sizes. It was decided the Bradford Hill viewpoints of causality could be usefully applied to the exercise for RCRSP literature to evaluate its causal claim. The findings of this review could not refute or corroborate the causal claim of exercise therapy but does highlight modifiable limitations in the literature that may warrant consideration and rectification.

Chapter 9 is the concluding chapter of this thesis. It contextualises the findings of this research program with the wider evidence base, acknowledges the strengths and limitations of conducted research and provides recommendations for future research. This research program maps and critically discusses the causal mechanisms that may underpin the effectiveness of an exercise program for an individual with RCRSP from a variety of perspectives. However, it must be acknowledged, there is still considerable research to undertake and progress to be made in order for a satisfactory explanation of the effect of exercise to be formulated. In the spirit of collaborative and iterative science, it is hoped this thesis may serve as a stepping stone on a continued pathway of discovery.

KEYWORDS

Rotator cuff, rotator cuff related shoulder pain, rehabilitation, exercise therapy, physiotherapy, physical therapy, resistance exercise, causal mechanisms

DECLARATION BY AUTHOR

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy (PhD).

This thesis represents my own original work towards this research degree and contains no material that has been previously submitted for a degree or diploma at this University or other institution, except where due acknowledgments is made.

Jared Powell

Date: October 21, 2024

DECLARATION OF AUTHOR CONTRIBUTIONS

Publication co-authored	Statement of contribution
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Assessing the effectiveness of exercise therapy for rotator cuff-related shoulder pain from a novel perspective. What can we learn from applying Bradford Hill’s viewpoints of causality? Under peer-review: <i>Shoulder and Elbow</i> Co-authors: Dr Ben Schram, Dr Jeremy Lewis, and Dr Wayne Hing.	JKP 85%, JL 5%, BS 5%, WH 5%

RESEARCH OUTPUTS

PEER-REVIEWED PUBLICATIONS

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3. E3 Rehab Podcast, Episode 144: *Rotator Cuff-Related Shoulder Pain* (April 2024). <https://podcasts.apple.com/au/podcast/144-rotator-cuff-related-shoulder-pain-w-jared-powell/id1484112288?i=1000652592521>

ETHICS DECLARATION

The research associated with this thesis received ethics approval from the Bond University Human Research Ethics Committee, ethics application number JP03070.

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ABBREVIATIONS

Consensus-Based Checklist for Reporting of Survey Studies	CROSS
Directed acyclical graph	DAG
Evidence-based medicine	EBM
Evidence-based medicine plus	EBM+
General practitioner	GP
Patello-femoral pain	PFP
Platelet-rich plasma	PRP
Randomised controlled trial	RCT
Rotator cuff related shoulder pain	RCRSP
Russo-Williamson Thesis	RWT
Transcutaneous electrical nerve stimulation	TENS
Western medical acupuncture	WMA

CHAPTER 1: Introduction

“The ability to create and use explanatory knowledge gives people the power to transform nature”.
David Deutsch

1.1 PREFACE

This thesis is presented in 9 chapters. Each chapter is self-contained and can be read and understood either individually or sequentially, from start to finish. When read sequentially this thesis is an iterative journey that explores the possible causal mechanisms underpinning exercise therapy for the management of rotator cuff-related shoulder pain (RCRSP).

RCRSP is the most common musculoskeletal condition of the shoulder joint and can cause profound disruption to activities of daily living and participation in valued activity. RCRSP has been evolving as a diagnostic label since first being described some 200 years ago. Currently, RCRSP is a preferred diagnostic label because there is uncertainty about how confident we can be with our clinical skills and radiological imaging to derive a specific pathoanatomical diagnosis to accurately and adequately explain an individual's shoulder pain. RCRSP can be considered analogous to non-specific low back of the lumbar spine and adductor-related groin pain of the hip/groin complex. The negative sequelae of RCRSP continues to fuel the ongoing pursuit of effective treatments to help manage associated signs and symptoms. Treatment options range from surgical to non-surgical, with non-surgical treatments such as education, exercise and manual therapy often recommended as frontline treatments. Most treatment options, both surgical and non-surgical, produce similar effects on shoulder pain and function, however, there are differences in risk profile, accessibility, and costs that needs to be considered by both patient and clinician. Exercise therapy is a recommended treatment for RCRSP, because it out-performs no treatment and usual care comparators and is generally well received by patients. However, while exercise therapy for RCRSP has a rich literature investigating its effectiveness, much less research has explored how and why it causes an effect. In other words, the causal mechanisms underpinning a reduction in shoulder pain or an improvement in shoulder function through engaging with an exercise program for individuals with RCRSP is currently obtruse.

The first chapter in this thesis introduces RCRSP and its history, briefly describes common treatment options for RCRSP and outlines the importance of causal explanation in health science. Moreover, the philosophical foundation that guides this thesis will be introduced and explained.

1.2 ROTATOR CUFF-RELATED SHOULDER PAIN: FROM PAST TO PRESENT

Approximately two billion people live with persistent musculoskeletal pain, and musculoskeletal conditions collectively are a leading cause of global disability (1-3). Shoulder pain is reported to be the third most common musculoskeletal presentation in primary care (4) and has a median point prevalence of 21% (5). It is estimated that 1% of adults consult a general practitioner (GP) with a new episode of shoulder pain every year (6), and the most common subgroup of shoulder pain is reported to be RCRSP (7, 8). RCRSP can disrupt numerous activities of daily living, including but not limited to, sleeping, dressing, attending to personal hygiene, household chores, working, social engagements, recreational pursuits, and caring for dependents (9-11). The clinical course of RCRSP is often intransient, with some reports suggesting 40-50% of individuals with a diagnosis of RCRSP will still have shoulder pain 6-12 months after pain onset (12).

It is worth briefly discussing the history of diagnostic terminology used to describe RCRSP before defining it in modern terms. The rotator cuff is well and truly entrenched in modern musculoskeletal medicine with its anatomy and function taught at educational institutions around the world. However, somewhat surprisingly, the first known illustration of the rotator cuff reportedly only dates back to 1788 (13, 14), and it wasn't until John G. Smith in 1834 when rotator cuff tears as a pathology were formally described in a series of post-mortem evaluations (15). In the early 1900s, Meyer and Codman each put forward theories to explain the aetiology of rotator cuff tears, with Meyer favouring attrition (impingement) and Codman espousing trauma (14). In 1949, J. R. Armstrong published a case series in *The Lancet* medical journal describing a clinical presentation he termed supraspinatus syndrome (16). Supraspinatus syndrome was believed to be a mechanical process whereby compression of the pathological supraspinatus tendon or subacromial bursa between the acromion and upper humerus caused pain (16). In the rare instances that supraspinatus syndrome did not self-resolve within "a few weeks", Armstrong advocated for the complete surgical excision of the acromion (16). In 1972 Charles Neer, the American orthopaedic surgeon, refined Armstrong's supraspinatus syndrome hypothesis, and formalised the concept of shoulder impingement syndrome (17). Neer hypothesised that impingement of the rotator cuff beneath the coraco-acromial ligament and anterior third of the acromion during arm elevation is responsible for the characteristic pain and disability associated with shoulder impingement syndrome, and that an anterior acromioplasty was the gold standard surgical remedy (17). Neer doubled down on his impingement hypothesis in 1983 and intrepidly claimed "*95% of rotator cuff*

tears are caused by impingement” (18). Neer proffered a three-stage process of impingement leading to rotator cuff tendon rupture: 1) oedema and haemorrhage, 2) fibrosis and tendonitis, and 3) bone spurs and tendon rupture (18). These seminal publications from Neer arguably changed the course of orthopaedic and physiotherapeutic diagnosis and management of shoulder pain for the next 50 years (19). This claim is supported by a recent scoping review which reports that 75% of diagnostic labels used to describe RCRSP from 1972-2019 reference impingement in the label (20), making a strong case for subacromial impingement to be the dominant explanation for non-traumatic shoulder pain since its proposal in the 1970s.

What is the evidence supporting impingement as the primary cause of rotator cuff tears and shoulder pain? It is important to note the evidence supporting Neer’s impingement hypothesis was never robust, in fact, Neer’s original studies have been compared to a modern-day blog in terms of their scientific rigour (19). As such, there is a large body of evidence that has developed, particularly over the past 15 years, which has consistently challenged the impingement hypothesis as proposed by Neer. (21). The current prevailing view is that the development of rotator cuff pathology is a multifactorial process involving a rich and diverse array of modifiable and non-modifiable variables (22). Common risk factors are known to include age, genetics, sex, co-morbidities such as type II diabetes and hyperlipidaemia, occupation, and handedness (22). The role of bony morphometry and morphology in the development of rotator cuff pathology is more opaque. Bigliani, in 1986, proposed a model that demarcated the acromion into three types: type I was a flat shape, type II was curved, and type III was hooked (23). Significantly, Bigliani claimed there was a strong relationship between the presence of a full thickness rotator cuff tear and a type III acromion (23). Despite early support for Bigliani’s acromial classification as a valid explanation for the development of rotator cuff pathology and indeed guide for subsequent treatment (24), more recent studies report conflicting results of the possible association between acromial morphology and rotator cuff tears (25, 26). There is also a question about the inter-rater reliability of Bigliani’s classification system (27), and evidence even suggests acromial morphology may be dynamic, capable of changing with age, as demonstrated by research where type III acromia were found to be more common in age groups over 50 years (28, 29). This finding confounds the supposed one-way causal relationship between acromion type and rotator cuff pathology. Acromial morphometry quantifies the angle of the acromion and its relationship with rotator cuff pathology. The critical shoulder angle is a common measure believed to be associated with rotator cuff pathology and there is moderate evidence supporting this hypothesised relationship (30). However, there is also evidence challenging the reliability and clinical meaningfulness of this relationship (31). Going

beyond rotator cuff pathology and simple structure, there is compelling evidence that challenges, if not refutes, impingement theory as a primary explanation of shoulder pain. Subacromial space distances do not differ between individuals diagnosed with shoulder impingement and pain free controls (32) and there is no evidence that the subacromial space distance mediates improvements in shoulder pain and function (32). Moreover, level 1 evidence from two placebo controlled trials reports subacromial decompression surgery is no better than sham surgery (33, 34), and current clinical practice guidelines strongly recommend against subacromial decompression surgery in favour of non-surgical management (35). Evidence from qualitative research reveals the profound impact a diagnosis of shoulder impingement can have on an individual's beliefs about what's causing their pain and what's the best treatment option for them. Research from Cuff and Littlewood in 2018 reported individuals diagnosed with impingement tend to believe their shoulder pain is due to mechanical abrasion of the rotator cuff underneath the overlying acromion, and that fixing their pain requires a surgical procedure to remove the offending lesion (36). Moreover, a diagnosis of shoulder impingement has also been linked with a higher perceived need of requiring radiological imaging (37), despite an absence of evidence to support routine imaging for non-traumatic shoulder pain.

Taken together, the impinging lesion or aberrant mechanical process that was hypothesised to drive shoulder pain need not change for an individual to experience a significant improvement in shoulder pain and function, calling into question the veracity of the impingement theory and diagnostic label. Furthermore, the psychological impact of labelling an individual with shoulder pain as shoulder impingement can have downstream negative consequences regarding beliefs about what treatment they require, which is often not based on the best available evidence.

If not impingement, then what? Many diagnostic labels have been proposed and used in clinical research, each with strengths and weaknesses. Whilst impingement predominates, other labels that focus on structural pathology, such as rotator cuff tendinopathy/tendonitis/tear are also popular (20). However, the fundamental problem with diagnostic labels that attempt to incriminate a pathological structure is the inconsistent relationship between the experience of shoulder pain and pathoanatomical findings observed radiologically or arthroscopically. Extensive literature challenges the traditional view of an isomorphic relationship between structural pathology of the shoulder, such as partial thickness and small full thickness rotator cuff tears, tendinopathy, labral alterations, acromioclavicular joint osteoarthritis, and bursal thickening, and the experience of shoulder pain (38-40). An exception to this is radiological features of frozen shoulder and full

thickness rotator cuff tears of increasing size (>2.5cm) (39, 41). Thus, the inconsistent relationship between pathology of shoulder structures and the experience of shoulder pain undermines diagnostic labels grounded in pathoanatomy. Owing to issues with pathoanatomical diagnostic labels, more non-specific terms have been proposed. Terms such as subacromial pain syndrome, subacromial shoulder pain, non-specific shoulder pain, and RCRSP are common diagnostic labels that have been used in clinical research and practice, and each are credible. Indeed, there is no universally agreed upon term to describe the clinical presentation, and rather than an exhaustive commentary about the subjective merits of each label, it is arguably more worthwhile to discuss the decision to use RCRSP in this thesis. RCRSP is a term formally proposed in 2016 by Jeremy Lewis and is a clinical hypothesis that may be posited when a stiff or unstable shoulder is not suspected, and there are no current clinical signs and symptoms of sinister, or adjacent pathology (e.g. the neck), that may be referring into the shoulder complex (42). The label RCRSP is an over-arching diagnosis that subsumes common pathoanatomical diagnoses, such as rotator cuff tear, tendinopathy and subacromial bursitis and often presents as shoulder pain during arm elevation and/or external rotation (42). Due to this, RCRSP has garnered support as a preferred diagnostic label amongst shoulder experts (43, 44) and practicing clinicians (45). Whilst RCRSP specifically mentions a structure (the rotator cuff), it stops short of affixing a ‘front of mind’ pathological label to the diagnosis, which is an important detail (46). The rotator cuff itself is a muscle/tendon complex that most lay people have heard of and are capable of understanding its function. From a health literacy perspective, it is crucial to use language that is as clear as possible to maximise patient understanding of the relevant health information (47). Karl Popper, the philosopher of science, states that “*we should always aim to speak as simply, as clearly and unpretentiously as possible*” and referencing a muscle and tendon in a diagnostic label is arguably simpler and easier to understand compared to the obscure anatomical region that is the subacromial space, for example.

The decision to use RCRSP as the diagnostic label for this thesis was a judgment call based on the available evidence. Terminology in health care is often hotly debated, owing to its subjective properties, however the totality of quantitative and qualitative evidence, including surveys of clinicians and consensus studies of shoulder experts, suggest RCRSP is a valid diagnostic label.

1.3 TREATING ROTATOR CUFF-RELATED SHOULDER PAIN

There are myriad treatment options to help individuals with RCRSP. They include advice and education, exercise therapy, manual therapy, electrophysical agents, dry needling and

acupuncture, injection therapy and surgery. In the following sections we will explore the evidence underpinning common treatments provided to individuals with RCRSP.

1.3.1 Surgery

Surgery for RCRSP, once a gold standard, has come under scrutiny over the past decade. Specifically, rotator cuff repair and subacromial decompression surgeries have been subjected to rigorous testing in clinical trials, and the results have been underwhelming in terms of efficacy and effectiveness. Rotator cuff repair surgery, according to the most recent Cochrane review, does not provide additional benefit when compared to exercise therapy, with or without corticosteroid injection (48). Historically, it had become increasingly accepted that individuals with non-traumatic rotator cuff tears could benefit from non-surgical management (49), however, recent evidence reports that individuals with rotator cuff tears sustained via a traumatic mechanism can also do well with either surgical or physiotherapeutic treatment (50). This challenges the role of surgical rotator cuff repair in patients with both traumatic and non-traumatic rotator cuff tears. At the time of writing, there have been no published randomised placebo-controlled trials investigating the efficacy of rotator cuff repair. However, there are two ongoing trials, the ARC trial (based in Australia) and the ACCURATE trial (from Finland, Sweden, and Norway) (51), that are actively exploring this research question. Publication of these trials will likely significantly alter the treatment landscape for RCRSP. It is relatively uncommon for orthopaedic surgeries to be subjected to a placebo comparison in a RCT, or even a non-surgical comparator for that matter, and when they are there is often found to be little to no additional benefit of the selected surgery (52, 53). Subacromial decompression surgery is one of the few orthopaedic procedures to be rigorously evaluated in a placebo-controlled RCT. Results of two high quality trials report no clinically important differences in pain outcomes between a ‘real’ subacromial decompression surgery and a ‘sham’ surgery (33, 34), for up to 5 years (54). These trials appear to have made an impact at the level of clinical practice, with the incidence of subacromial decompression surgeries falling over the last decade (55, 56). In a Nietzschean philosophical sense, in which humankind is encouraged to find meaning and morality in the aftermath of the ‘death of God’, the collapse of a gold standard surgical procedure to help individuals with RCRSP has hastened the need for effective non-surgical treatments.

1.3.2 Injection therapy

Injection therapy refers to the injection of chemical substances into the subacromial space and/or rotator cuff tendons of the shoulder complex. Principally, injections take the form of corticosteroids, platelet rich plasma, anaesthetic, and occasionally prolotherapy or saline.

Corticosteroids are the most common injection type, with some reports suggesting up to 96% of clinicians consider and trust corticosteroid injections as a valid and effective treatment option for RCRSP (57). Furthermore, a survey of Australian GP practice reported that GPs refer for corticosteroid injections twice as frequently as referrals for physiotherapy (7). However, despite the popularity and ubiquity of corticosteroid injections, robust evidence supporting their effectiveness is sparse. Evidence currently indicates that a corticosteroid injection may provide inconsistent short term pain relief for individuals with RCRSP, however medium- and long-term outcomes are equivocal when compared to placebo or non-injection comparators (58, 59). The inconsistent short term pain relief is confounded by the finding that a corticosteroid injection has a number needed to treat of five, meaning that five individuals with RCRSP would have to receive a corticosteroid injection for one individual to experience a benefit greater than a placebo injection (60). A recent high quality RCT reported that a corticosteroid injection combined with an exercise program did not provide a clinically meaningful benefit compared to an exercise program alone (61).

Corticosteroid injections have a modest effect on an individual's shoulder pain, but could they worsen it? This is a common suggestion and has led to the popularisation of the mantra, “short term gain for long term pain” (62). Mechanistic studies report that corticosteroids can plausibly induce a toxic effect on soft tissues of the shoulder (63, 64) and thus do have a risk profile that needs to be jointly considered by clinicians and patients. Moreover, there is evidence from a retrospective cohort study that reports individuals who received a corticosteroid injection had a 7-fold higher incidence of sustaining a rotator cuff tear compared to those who did not receive an injection. This is not evidence of causation, due to the design of the study, but in conjunction with mechanistic evidence, certainly raises questions about the safety of corticosteroid injections. In sum, corticosteroid injections may provide short term pain relief for some individuals with RCRSP, however this effect is lost at mid- and long-term follow-up, and there are questions over its safety profile.

Platelet-rich plasma (PRP) is another injection type hypothesised to be effective for RCRSP and has been an area of burgeoning research interest over the past 20 years (65). The mechanism of action of PRP is purported to be its healing properties and anti-inflammatory effects, although it remains unclear exactly how and why PRP may reduce shoulder pain and improve shoulder function (66). Whether PRP actually enhances healing of rotator cuff tears is disputed according to current level 1 evidence (67). There is limited evidence supporting the efficacy of PRP for RCRSP (68), and they may be inferior to corticosteroid injections, especially in the short-term (69). However, PRP does not come with the same baggage as corticosteroid injections regarding possible

deleterious effects on soft tissue. It must be questioned whether it is logical to base a treatment on improving soft tissue structure when soft tissue structure has an inconsistent relationship with the experience of shoulder pain (70). In the one RCT that directly compared PRP with an exercise program in a cohort of individuals with RCRSP, exercise was shown to out-perform PRP in the short-term and outcomes were equivocal in the medium-term (71). Thus, the evidence-base for PRP is currently uncertain and it's unclear whether it out-performs placebo, other injection types, or exercise therapy.

Other injection types that have been researched for RCRSP are local anaesthesia and prolotherapy. Anaesthetic injections are comparable to corticosteroid injections at medium- and long-term follow-ups but may be inferior in the short-term (72). It is speculated that anaesthetic injections have a better safety and cost profile compared to corticosteroid injections, and thus might be a viable alternative (72). Prolotherapy involves the injection of an irritant, usually a dextrose solution, into and around a pathological area to stimulate regeneration of the damaged tissue (70). Some studies suggest prolotherapy is an efficacious treatment for RCRSP, however the literature is plagued by studies with a high degree of bias that renders attempts at drawing definitive conclusions about the efficacy of prolotherapy challenging (73).

Overall, various injection types have been trialled for RCRSP, with underwhelming effects. Corticosteroid injections have the most robust evidence for providing short-term pain relief, but these effects washout at mid and long-term follow-ups, and there is concern over its safety profile. PRP has minimal evidence in support of its effectiveness, anaesthetic injections may be a viable and safer alternative to corticosteroid injections, and more rigorous research is required investigating prolotherapy.

1.3.3 Physical therapies

The frontline recommended treatment for RCRSP is non-surgical management (74). Non-surgical management may include anything from 'wait-and-see', to simple pharmacology, to referral to an allied health professional, such as a physiotherapist (75). A physiotherapist has scope of practice to utilise a number of different treatment options, including manual therapies, dry needling and acupuncture, and electrotherapeutic modalities (76). Manual therapy is a core component of traditional physiotherapy care and includes both thrust and non-thrust manipulation of bodily joints and soft tissues (77). A modern definition of manual therapy encourages a paradigm shift away from emphasising passive care to a systematic active approach that is person-centred and also involves appropriately dosed exercise therapy (77). Manual therapy is a recommended

treatment for RCRSP (76, 78), however it is often advised to use only in conjunction with an exercise program (74, 77). There is low-moderate certainty evidence that manual therapy has a significant but uncertain clinical effect for reducing pain associated with RCRSP (79). There is conflicting evidence pertaining to whether adding manual therapy to an exercise program confers superior outcomes compared to exercise alone. A recent RCT found a significant effect for adding manual therapy to an exercise program in improving long-term shoulder pain and disability (80), however, somewhat surprisingly, there was no short term effect. The results of this trial must be interpreted with due consideration of the study design, A VS A + B, which has been suggested to be associated with a higher rate of false positive findings (81). Furthermore, current meta-analyses contradict this RCT finding, reporting no additional benefit of adding manual therapy to an exercise program for improving shoulder pain, function, and disability (82). Taken together, the most prudent use of manual therapy for RCRSP appears to be in conjunction with an exercise program, which is concordant with current guideline recommendations (74) and definitions of manual therapy (77).

Dry needling involves the skilled insertion of a fine filiform needle into a painful/sensitive muscle (commonly called a trigger point) to reduce musculoskeletal pain (83). There is low-moderate quality evidence that trigger point dry needling can reduce shoulder pain in the short term, but it is unclear if this effect is clinically meaningful (84). It should be acknowledged there are many types and variations of dry needling, however, trigger point dry needling is the most common method practiced by physiotherapists. There is also ongoing debate pertaining to the concept of a muscle trigger point, whether it can be accurately identified in clinic, and precisely how trigger point dry needling is hypothesised to have an effect (85). Western medical acupuncture (WMA) is a type of acupuncture within the scope of physiotherapists, introduced as a derivative of traditional Chinese acupuncture, that involves the insertion of fine needles into muscle trigger points, as opposed to traditional acupuncture meridian points (86), although there is some overlap between traditional acupuncture points and the location of common muscle trigger points (87). The overall effectiveness of WMA for RCRSP is uncertain according to the most recent Cochrane review (88) and it is unclear whether adding acupuncture to an exercise program provides any additional benefit compared to exercise alone (89). Overall, dry needling and acupuncture may attenuate shoulder pain in the short term but there is no evidence that it is superior to other treatments such as exercise and education, and thus the current recommendation is to provide dry needling and acupuncture within a multimodal management approach (90).

The application of electrophysical agents has traditionally been commonplace in physiotherapy practice, however, the advent of evidence-based medicine in the 1990s has challenged its primary position (90). There are many varieties of electrophysical agents, including laser, ultrasound, shockwave, and transcutaneous electrical nerve stimulation (TENS). All varieties aim to stimulate a bodily part via the application of external energy, with the exact type of energy mattering little. The evidence supporting electrophysical agents for managing RCRSP is limited (74, 91, 92), and once again, the current recommendation is to use electrophysical agents judiciously as part of a multimodal treatment package (90), if at all (93).

1.3.4 Exercise therapy

Exercise therapy is a popular and recommended frontline treatment for managing RCRSP. The popularity of exercise therapy amongst musculoskeletal clinicians worldwide is emphasised by surveys of physiotherapy practice reporting that up to 99% of surveyed clinicians provide a form of exercise for a patient with RCRSP (94-96). Clinical practice is concordant with recommendations from clinical practice guidelines and systematic reviews, which consistently recommend the provision of exercise for individuals with RCRSP as a priority (74, 76, 97). When exercise is provided to individuals with broad spectrum tendinopathies, including RCRSP, it is often positively received and associated with moderate-high levels of patient satisfaction (98).

Exercise and movement therapy are woven into the fabric of physiotherapy, and human movement has been observed, measured and adjusted by skilled physiotherapists for more than a century (99). Broadly, exercise is a subcategory of physical activity, where physical activity is “*any bodily movement produced by skeletal muscles that results in energy expenditure*” (100). Exercise, on the other hand, goes beyond physical activity and is “*planned, structured, repetitive, and purposive physical activity designed to improve aspects of health and physical fitness*” (100). Physical fitness is a set of attributes that people have or achieve and is commonly divided into two groups (100):

- Health-related components
 - Cardiorespiratory endurance
 - Muscular endurance
 - Muscular strength
 - Body composition
 - Flexibility
- Skill-related components

- Agility
- Balance
- Coordination
- Speed
- Power
- Reaction time

Exercise, as it pertains to RCRSP rehabilitation, is a heterogeneous intervention and in the literature takes many different forms, including:

- Resistance exercise
 - Concentric, eccentric, isotonic, and isometric biased muscle contractions
- Motor control exercise
- Postural exercise
- Stretching exercise
 - Static and dynamic stretching types
- Proprioceptive neuromuscular facilitation exercise
- Neurodynamic exercise
- Plyometric exercise
- Open and closed kinetic chain exercise

Exercise therapy for managing RCRSP is a modestly effective treatment when compared to natural history, usual care, and other non-surgical approaches (101-103). However, exercise has hitherto failed to out-perform a placebo comparator in a high-quality clinical trial (104), raising questions about its efficacy. There is also enduring uncertainty about whether there is an optimal exercise approach or dose for managing individuals with RCRSP (105, 106). The reporting of exercise interventions in clinical trials is consistently poor, which confounds interpretation, application, and replication of the exercise program in future research and clinical practice (107). This has led to the question, “*if exercise is medicine, why don’t we know the dose?*” (108). Thus, there are active questions about efficacy, overall treatment effectiveness, and the optimal anatomy of an exercise program for individuals with RCRSP.

In the profession of physiotherapy, exercise therapy has long been used within a reductionist and body-as-machine paradigm (99), where exercise is used as a tool to correct or improve a measurable physical attribute (s) thought causally related to an individual’s clinical presentation. This often takes the form of ‘finding and fixing’ an observable aberrant movement pattern or strength deficit via an appropriately designed exercise program. Any resulting changes to an

individual's pain are then conflated with changes to the targeted physical attribute, for example muscle strength. What is the evidence supporting this tradition of thought? This will be expounded upon later in this thesis (Chapters 3-8). First, we must turn unpack the concepts of mechanisms, mediators, and causal explanation to be able to fully wrestle with these causal questions.

1.4 THE IMPORTANCE OF CAUSAL EXPLANATION

The philosopher of science, Karl Popper, suggests the aim of science is to find satisfactory explanations of worldly phenomenon (109). Physicist and philosopher, David Deutsch, goes further and suggests explanation is essential to knowledge creation, progression and the prospering of the human species (110). Explanation, according to the Oxford Learner's Dictionary, is a "*statement, fact, or situation that tells you why something happened; a reason given for something*".

Operationally, an explanation is a causal proposition attempting to satisfactorily account for how and why some event or phenomenon took place. Asking questions about how and why, in other words seeking causal explanations through a systematic process of trial-and-error, is inherent to the human condition, and has been postulated as a defining characteristic of what separates modern humans from other species (111). The transformative power of causal explanation has been appreciated in science and philosophy for at least 100 years, with some suggestions it can be traced back further to the ancient Greeks (112), however, in the field of physiotherapy and health science an argument can be made that it has been not been given adequate attention. Later in this chapter we will discuss some pertinent examples from medicine to illustrate the importance of causal explanation for both facilitating and hindering medical progress.

1.4.1 Mechanisms

A mechanism is invoked to explain (113), is an essential component of an explanation, and for the purposes of this thesis, causal mechanism and causal explanation are used interchangeably. A mechanism can be defined as an "*epistemic model that enables the explanation of how phenomena are causally brought about*" (114). In realist philosophy, a mechanism is usually hidden, is sensitive to variations in context, and generates outcomes (115). This means that mechanisms can only be properly understood by going beyond statistical correlation and regularities. It also means mechanisms can be either dormant or active depending on the context and can generate outcomes (115). In physiotherapy and health science, the identification of causal mechanisms (sometimes referred to as mediators) helps to understand how a treatment works, or why it doesn't. Without knowledge of treatment mechanisms, our understanding of the purported effectiveness of a treatment is superficial and descriptive in nature, oft-called a 'black box'

approach to causality that focuses on statistical correlation (effects) and undervalues or dismisses how these effects were generated (115, 116). This ‘black box’ approach to causality can go awry and lead to potentially useful treatments and theories being overlooked (117). The history of science is replete with examples of hypotheses being rejected by the scientific community because of the absence of a valid mechanism which satisfactorily explains how and why the phenomenon under investigation came to be. Perhaps the most stunning example is Darwin’s theory of evolution (evolution by natural selection), which was considered an incomplete theory until it merged with Mendel’s theory of genetic inheritance. Mendelian genetic theory provided the missing mechanism that solidified Darwin’s theory of evolution, changing the course of history (118). In the following two sections we will briefly discuss historical examples from the field of medicine to convey the importance of investigating and identifying causal mechanisms.

1.4.2 Doctor James Lind and Scurvy

In 1747, Scottish Doctor James Lind, discovered an effective treatment for the dreaded disease, Scurvy. Scurvy is estimated to have killed millions of sailors and long-haul explorers between the years 1500 -1800 (111). Lind famously conducted a controlled experiment and discovered that oranges and lemons (citrus fruits) were able to cure the signs and symptoms of scurvy in British Sailors (119). However, despite the impressive results of observed by Lind, Scurvy remained a scourge afflicting those on long-haul expeditions because the causal mechanism underpinning the effect of the citrus fruit treatment remained unknown. A century later, Lind’s treatment was forgotten, perhaps ignored, and other theories on the cause of Scurvy, such as tainted meat, prevailed (111). The causal explanation for the initial successful results of citrus fruit treatment was thought to be the acidity of the specific fruit, not vitamin C, which we now know to be the mechanism. Thus, anything that was acidic was trialled, with subsequent poor outcomes. On some occasions, the lime or orange juice was even boiled (purified), killing off all the crucial vitamin C. Thus, the citrus fruit theory for treating and preventing scurvy was eventually rejected. It wasn’t until the discovery of Vitamin C in 1928 that the mechanism underpinning the effectiveness of citrus fruit for treating scurvy was substantiated (119) and Scurvy is now mostly a relic of the past. In this historical example, the latent identification of a mechanism was critical for establishing the validity of the effectiveness of citrus fruit for treating scurvy. Even though Lind ‘proved’ that citrus fruit was an effective preventative and treatment for Scurvy, the absence of a valid causal mechanism undermined its credibility, effectiveness, and widespread uptake. Mechanisms matter.

1.4.3 Doctor Ignaz Semmelweis and handwashing

In the year 2024, there is no doubt that handwashing is an important hygiene measure. Unfortunately, we have recent lived experience of this with the COVID-19 pandemic that gripped the world in 2020, reiterating the importance of hand hygiene for preventing the spread of communicable germs. However, perhaps surprisingly, germ theory hasn't always been an accepted scientific theory. Ignaz Semmelweis (1818 – 1865) was a Hungarian doctor who specialised in Obstetrics at the Vienna Maternity Hospital. Infamously, the hospital was divided into two wards, with ward 1 having a mortality rate 2.5x higher than that of ward 2 (120). Ward 1 was overseen by doctors and medical students (all male) and ward 2 was overseen by doctors (all male) and midwives (all women). Semmelweis was perplexed by the significantly higher mortality rate in post-partum women in ward 1 and set out to solve the problem (find a causal explanation). The condition afflicting women at a higher rate in ward 1 was Puerperal fever, mercifully now cured thanks to Semmelweis, and all manner of weird and wonderful hypotheses were proposed to account for the significant difference between the two wards. Hypotheses included putrid air, overcrowding, rough examination methods from medical students, and even the psychological effect of priests delivering last rights to fellow patients (120). Semmelweis instituted solutions to all of the preceding hypotheses to no avail.

It wasn't until a colleague of Semmelweis contracted a very similar condition to that of Puerperal fever that he had a moment of genius. Semmelweis colleague was conducting an autopsy when he was cut on the hand from a medical student, subsequently falling ill. Semmelweis hypothesised that the open wound on the hand was exposed to cadaverous matter during the autopsy causing his condition and wondered whether something similar was happening in ward 1. Doctors and medical students would examine patients in ward 1 directly after dissecting corpses and thus possibly transmitting cadaverous matter to their patients (120). Ward 2 was less affected by this as midwives would not conduct autopsies, thereby possibly explaining the difference in mortality rate between the two wards. Semmelweis instituted a thorough handwashing protocol with disinfectant before doctors and medical students could examine their patients, which dramatically reduced the mortality rate of ward 1 in line with ward 2 (120). However, although the handwashing regimen was effective, the mechanism put forward by Semmelweis was challenged and ultimately rejected, for often absurd reasons.

Germ theory was still a fringe hypothesis at the time, and some doctors even took offence that they (gentlemen!) could be to blame for harming their patients (121). The Semmelweis story doesn't have a happy ending. After his post at the Maternity Hospital his contract was not renewed,

struggled to gain employment, was shunned by the medical community, and ended up dying (ironically from infection) in a mental asylum (120). The year of Semmelweis death in 1865 was the year Joseph Lister made antiseptic measures such as cleaning surgical instruments and wounds mainstream, after reading the work of Louis Pasteur, and Lister would go on to be credited, along with Pasteur, as the founding fathers of germ theory. Semmelweis was largely forgotten. We could argue that if germ theory was a more accepted theory of disease at the time of Semmelweis handwashing hypothesis, in other words if there was a valid causal power linking the examination of cadavers and subsequent infection in post-partum mothers at the hands of doctors and medical students, Semmelweis would have been celebrated rather than snubbed. More importantly, perhaps some lives would have been saved. Again, mechanisms matter.

1.4.4 Treatment mechanisms in physiotherapy

Clinical outcomes, such as reducing pain and disability, are important for people with musculoskeletal pain (122). However, these outcomes aren't directly targeted by treatments. Rather, various physiotherapy treatments must target hypothesised intermediary variables (mediators) that are presumed causally associated with a specific outcome (e.g. shoulder pain) (123). For example, in common physiotherapy management of RCRSP, stretching exercise is often used to lengthen the pectoralis minor muscle and this (potential) change in muscle length will then, in turn, improve shoulder pain and disability, or so the theory goes (124). Similarly, glenohumeral joint mobilisations are hypothesised to reduce shoulder pain via improving joint mobility. In both examples, a key intermediary variable is targeted by the treatment, and any positive change in that intermediate variable is then expected to influence a specific outcome, such as shoulder pain.

Exercise therapy for RCRSP is considered a complex intervention as it is capable of influencing outcomes such as shoulder pain and disability via various interacting biopsychosocial pathways (125). In the evaluation of complex interventions, such as exercise therapy, it is recommended to investigate how the interventions works: what are the active ingredients and how are they exerting their effect? (125). The evidence for exercise-based management of RCRSP is replete with RCTs that broadly explore the effect of an exercise program compared to some other group on some outcome of interest, often shoulder pain and function. RCTs, while of immense importance and influence in evidence-based medicine, offer limited information about precisely how a particular treatment caused a specific outcome – the 'black box' phenomenon discussed previously (116). Thus, we are left to speculate and rely on imprecise theoretical rationales for how and why an effect may or may not have occurred in a specific group who were exposed to a

particular treatment (126). One way to escape this ‘black box’ is to employ a statistical approach called mediation analysis.

1.4.5 Mediators and mediation analysis

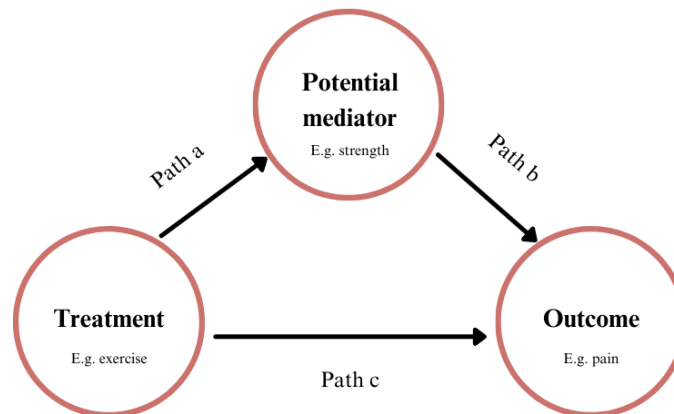
A mediator, or intermediate variable, is a variable that may be affected by an exposure (treatment) and, in turn, may affect an outcome of interest (127). Mediators are modifiable and can change in response to a treatment (126). A moderator, in contrast, is a baseline variable that can alter the direction or magnitude of the effect of an exposure on an outcome (127) and can be used to stratify those who may or may not respond to a particular intervention (126). In short, a mediator is a modifiable variable that channels the effect of a treatment onto an outcome of interest.

Mediation analysis can help partition the different pathways that could explain the effect of a treatment on an outcome. Mediation analysis is often used when a “researcher wants to assess the extent to which the effect of an exposure is explained or is not explained by a given set of hypothesised mediators” (128). Studies that don’t use causal mediation analysis can only speculate about the mechanisms through which a treatment did or didn’t work, and this is an important limitation (129). Mediation analysis can overcome this limitation by helping to identify how and why a treatment leads to an effect by the identification of mediating variables (130). Mediation analysis provides a consistent and rigorous estimate of the degree to which treatments work through selected causal mechanisms (mediators) (131). Subsequently, these mediators can be targeted by clinicians in clinical practice, and thus have a practical application.

When this research program commenced in 2018, and indeed at the time of confirmation of candidature in 2021, to the best of my knowledge, no mediation analysis of exercise therapy for RCRSP had been published. As such, no empirically verified mediators were available that could explain the relationship between exercise therapy and improvements in shoulder pain and function. However, despite the absence of evidence, we are able to hypothesise possible mediators based on their theoretical plausibility, using basic science mechanistic evidence, and by using evidence of analogy from other similar musculoskeletal presentations (132). Possible causal relationships can also be modelled using directed acyclic graphs (DAGs), which are a graphic approach for representing causal relationships between variables (Figure 1) (127). For example, motor control exercise (treatment) may be utilised to improve shoulder pain and disability (outcome) via optimising scapular kinematics (mediating variable) (Figure 2). Moreover, humeral head centring exercise (a subset of motor control exercise) might be used to improve shoulder pain and disability via increasing acromiohumeral distance. Regarding psychosocial constructs, pain self-efficacy

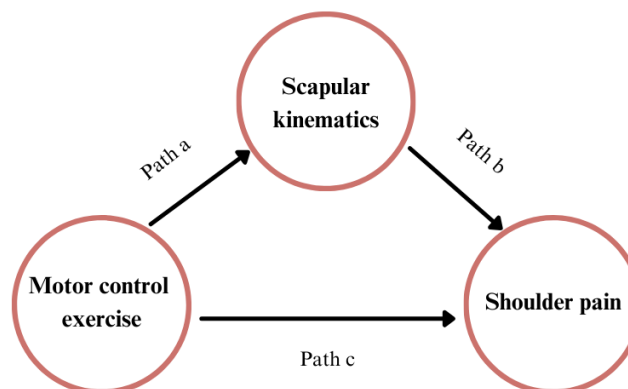
might be enhanced via the application of shoulder exercise, and this might subsequently mediate improvements in pain and disability. Shoulder exercise may also improve pain and disability by influencing neuroimmune variables, such as inflammatory cytokines.

Figure 1: DAG showing hypothesised causal relationship between treatment-mediator-outcome



Legend: Path c = direct effect of treatment on outcome. Paths a + b = indirect (mediating) effect. Paths ab + c = total effect

Figure 2: DAG mapping hypothetical causal relationship between motor control exercise and shoulder pain reduction



Legend: Path c = direct effect of treatment on outcome. Paths a + b = indirect (mediating) effect. Paths ab + c = total effect

1.4.6 Evidence-based medicine plus and the Bradford Hill viewpoints of causality

During this introduction we have discussed the historical importance of mechanisms in science broadly, medicine and health science specifically, and outlined the current dearth of rigorous mechanistic evidence regarding exercise therapy for RCRSP. There is a modern-day movement, evidence-based medicine plus (EBM+), that is seeking to place evidence of mechanisms on equal footing with evidence derived from RCTs and other clinical studies. This is guided by the

theory of evidential pluralism, which asserts both evidence of correlation and evidence of mechanisms are needed to establish a causal claim (113). Evidence-based medicine (EBM) traditionally ranks different evidence types hierarchically, and positions evidence from RCTs and their meta-analyses as the most reliable and credible sources of information (133). Mechanistic evidence is often relegated to the bottom of the hierarchy, or not included at all (133). EBM+ is based on the Russo-Williamson Thesis (RWT) which contends that:

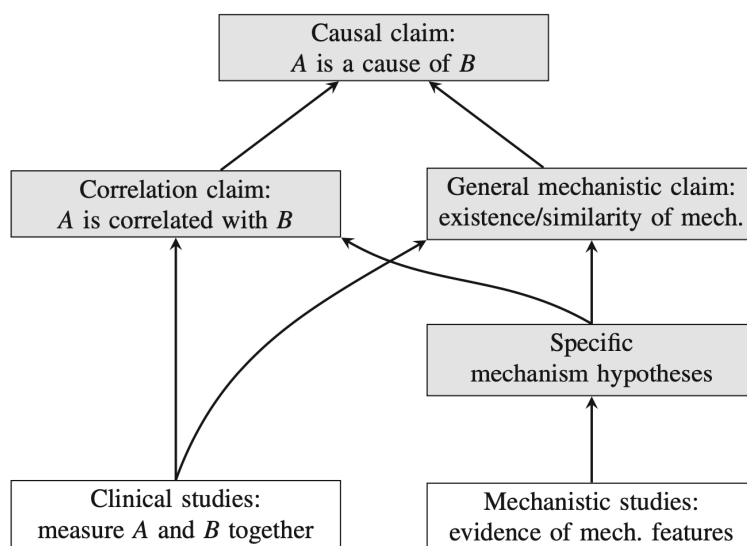
“In order to establish a causal claim in medicine one normally needs to establish two things: first, that the putative cause and effect are appropriately correlated; second, that there is some mechanism which explains instances of the putative effect in terms of the putative cause and which can account for this correlation” (134).

EBM+ is clear in stating that both mechanistic evidence AND probabilistic evidence (derived from RCTs and observational studies) are of equal import for establishing a causal claim, and the existence of one without the other weakens its claim (Figure 3) (134). EBM+ does not devalue the critical importance of probabilistic evidence, but rather seeks to highlight the crucial role of identifying valid causal mechanisms to complement probabilistic evidence.

Mechanistic evidence has a poor reputation in modern EBM because of historical baggage and the concept of *mechanistic storytelling* or *reasoning* (135). The most striking example of *mechanistic reasoning* gone wrong is the advice to put babies to sleep on their front rather than their back to prevent babies choking on their vomit and thus preventing sudden infant death syndrome. This advice, based on seemingly plausible *mechanistic reasoning*, turned out to be dangerous and did more harm than good (113). The criticism of *storytelling* is related to this sad example. It is possible to explain, in principle, any phenomenon you like, as abstractly as you like, through *mechanistic reasoning* or *storytelling*. For example, the ancient Greeks believed the god of water, Poseidon, was responsible for rough seas, tsunamis and earthquakes. As naïve as it seems today with our current knowledge of meteorological science, this was a valid causal explanation for the time, albeit false. Closer to health science, weird and wonderful explanations of health and disease have been proposed for millennia. The humoral theory of disease postulated disease was caused by imbalance between the four bodily humors, and treatment was needed to restore balance to the body. This may have taken the form of bloodletting, emetics and purging depending on the clinical presentation. If a patient improved with these remedies, the explanation was restoration of humoral balance. Again, this has turned out to be false but was biologically plausible for the time. Closer to the field of physiotherapy and allied health, innumerable fringe explanations for the onset of

musculoskeletal pain and its associated treatment abound. A quick scroll through social media yields images and videos of certified practitioners healing psychological trauma, sometimes even from past lives, by hovering their hands over a patient (this can apparently even be performed remotely via videoconferencing), offering outdated and implausible explanations for the effect of manual therapy in relieving musculoskeletal pain, and instructing individuals to blow up balloons to cure their back pain. The *mechanistic reasoning* for these treatments has very little or nil empirical support, yet their effectiveness in relieving pain can be very real. Herein lies a conundrum. Many fringe treatments may indeed help individuals with various clinical presentations, and could even be tested in a clinical trial, which may reveal a significant correlation between the treatment and an outcome, and thus counts as probabilistic evidence. However, the absence of a plausible, scrutinised and proven mechanism linking the two correlated variables is a vital missing piece and undermines its causal claim. EMB+ proposes there is a difference between *mechanistic reasoning* which is often based on how psychologically compelling a mechanism might seem, versus mechanism evaluation which involves judicious scrutiny of mechanistic research (113). This is an important distinction.

Figure 3: The role of statistical and mechanistic evidence for making causal claims



Legend: (Reproduced under [CC-BY-4.0](https://creativecommons.org/licenses/by/4.0/) License from Parkkinen et al. (113)). DOI: [10.1007/978-3-319-94610-8](https://doi.org/10.1007/978-3-319-94610-8)

The Bradford Hill viewpoints of causality are an antecedent to EBM+ and represent an early example of evidential pluralism (113). Austin Bradford Hill (1897-1991) was an English epidemiologist and medical statistician, credited with conducting the first RCT in medicine, which tested an antibiotic for pulmonary tuberculosis (136). Bradford Hill had a distinguished career in epidemiology and was influential in identifying a causal association between tobacco smoking and

lung cancer (137). In order to demonstrate a causal association between smoking and lung cancer Bradford Hill devised nine viewpoints that may be considered for establishing a causal claim, because simply conducting a RCT investigating smoking and lung cancer was and is clearly unethical (132). The nine viewpoints are outlined in Table 1 below.

Table 1: Bradford Hill viewpoints with explanations

Bradford Hill viewpoint	Explanation of viewpoint
1. Strength of association	Magnitude of effect. A strong association is more likely to be causal than a weak one (138).
2. Consistency	Multiple observations made by different observers with different instruments mean the association is more likely to be causal (138).
3. Specificity	If an outcome is best predicted by one primary factor, the causal claim is more credible (138). In rehabilitation parlance: is an improvement in shoulder pain associated with a specific mechanism of exercise or are there other reasonable explanations? (139)
4. Temporality	A cause must precede an effect (138).
5. Biological gradient	There should be a direct dose-response relationship between the independent variable (exercise) and the dependent one (pain outcome) (138). In rehabilitation parlance: a higher dose of exercise should induce greater pain relief.
6. Plausibility	An association is more likely to be causal if there is a rational and theoretical basis for it. Mechanistic evidence is required (138).
7. Coherence	An association is more likely to be causal if it coheres with other knowledge about the natural history and biology of the condition under study (138). This can be useful for ruling out alternative explanations for a treatment's effects (133).
8. Experiment	Any related research that is based on experiments will make a causal inference more plausible (138).
9. Analogy	The likelihood of a causal relationship may be strengthened if a comparable association is observed between the same outcome and an analogous exposure or the same exposure and an analogous outcome (140). In rehabilitation parlance: if there is evidence from other musculoskeletal conditions of an association between exercise therapy and shoulder pain reduction, this may support causation and lower the burden of proof.

Legend: Adapted from Greenhalgh et al. (138) under [CC-BY-NC-4.0](#). Citation: Greenhalgh T, Flisman, D., Cane, D.J., Oliver, M., Macintyre, C.R. Adapt or die: how the pandemic made the shift from EBM to EBM+ more urgent. BMJ Evid Based Med. 2022;27:253-60. DOI: <https://doi.org/10.1136/bmjebm-2022-111952>.

Hill's viewpoints are notable in that they consider both mechanistic and clinical study evidence. The strength of association, which can be interpreted as effect size, accounts for one consideration that might be an indicator of causation. In contrast, several viewpoints, including specificity, biological plausibility, and coherence consider mechanistic evidence as important for making causal claims. This highlights the value of mechanistic evidence in establishing causal claims, particularly in cases when RCTs are challenging or unethical to conduct, inconclusive in their results, or inappropriate for the particular research question (133). Chapter 8 of this thesis interrogates this more deeply by applying the Bradford Hill viewpoints to the exercise therapy for RCRSP.

The philosophical spirit of EBM+ highlights deficiencies in the current physiotherapy evidence-base, particularly as it relates to exercise therapy for RCRSP, as there is a substantial knowledge gap pertaining to how exercise therapy may help an individual with RCRSP. It is reasonable to conjecture this knowledge gap could be limiting the effectiveness of exercise therapy in both research and clinical practice, adversely affecting the outcomes of patients, and even resulting in research waste and over-treatment. By understanding how a treatment works, or why it doesn't, could optimise clinical practice, giving the end-user of research (clinicians) a clearer picture on what treatment targets they should prioritise and what they should deprioritise.

1.5 PHILOSOPHICAL FOUNDATION

1.5.1 *Critical realism*

The philosophical foundation of this thesis is critical realism. Critical realism is not a specific research method but a comprehensive philosophy of science consisting of philosophical tenets that can guide quantitative, qualitative or mixed methods research designs, which aim to understand how and why phenomenon or events happen (142). Thus, critical realism espouses the pursuit of causal explanations, which marries well with the aims of this thesis. Common questions that a critical realist philosophy can be used to answer are: *how is the effect being caused? What triggers the activation of the causal mechanisms? What inhibits them?* (143, 144). Critical realism also encourages exploration of the context that may influence outcomes (142), which is important in health care research because many health care interventions are complex and at the mercy of many contextual factors (143). Critical realism was introduced by Roy Bhaskar in the 1970s and 1980s (145, 146) as an alternative philosophical approach to science than both positivism and

interpretivism, and its use in health research has grown in recent years as researchers increasingly recognise its suitability for exploring and understanding complex events and experiences (143). Critical realism posits that both positivist and interpretivist approaches to research are limited, falling victim to the ‘epistemic fallacy’, which conflates ontology with epistemology (146).

1.5.2 Ontology and epistemology

Critical realism, as the name suggests, is committed to a realist ontology. That is, there is a mind independent reality (142). This ontological position is concordant with classical positivist philosophy which continues to dominate quantitative research endeavours, but differs from interpretivism and constructivism which equate human perceptions of reality with reality itself (142). An example of a realist ontology applied to health care is an individual who smokes tobacco, who doesn’t believe smoking tobacco causes lung cancer, is still predisposed towards developing lung cancer, because the biological state of their lungs is not beholden to their beliefs (142). An example closer to the content of this thesis is a hypothetical person with a frozen shoulder. This person is profoundly limited into external rotation of the glenohumeral joint, with an equal restriction of active and passive range of motion, is 50 years of age, is unable to find a comfortable position to sleep during the evening and has type two diabetes. This person may be adamant they don’t have a frozen shoulder and instead they believe they have subacromial bursitis because their ultrasound scan report states so. No matter how much this individual believes they have subacromial bursitis, which they may actually have, it is likely the reality of their clinical presentation is that their pain and disability is being driven via nociception from the synovium and capsule of the glenohumeral joint, which is characteristic of frozen shoulder.

Critical realism departs from positivism and resembles constructivism and interpretivism in its epistemology. Critical realism asserts that whilst there is a mind independent reality, how individuals come to acquire knowledge of reality is subjective, fallible and contextual (141, 142). The philosophy of critical realism approximates Karl Popper’s critical rationalist epistemology (141, 147) as a critique of the philosophical assumptions of positivistic research, which holds that humans can fully and infallibly come to apprehend reality. Critical realism acknowledges the importance and value of human perspectives of reality but emphasises it is not synonymous with objective truth (141). Critical realism combines observation and interpretation in the pursuit of causal explanations and facilitates an understanding of the mechanisms that can influence outcomes (143). Thus, critical realism can be understood as integrating ontological realism with epistemological interpretivism (146), and as a result, is a unique and powerful approach to research that can harness the strengths of both philosophies.

1.5.3 The intersection between critical realism and complexity science

Exercise therapy for managing musculoskeletal conditions may be considered a complex treatment (125, 148). A treatment may be considered complex because of the number of components involved, the range of behaviours targeted, and the permitted level of flexibility of the treatments and its components (149). Complexity also emerges when treatments interact with their context, meaning the effects of a complex treatment may vary depending on the context it is delivered within (149). The United Kingdom Medical Research Council recommends evaluating the effectiveness of complex treatments by considering the mechanisms involved in producing an outcome and the conditions (context) that may have supported the treatment-mechanism-outcome relationship (149). Complex should not be conflated with complicated. Flying a rocket to the moon is complicated but if the complicated and intellectually demanding steps are followed correctly, a successful moon trip is, in principle, relatively predictable (148). Conversely, raising a child is complex because even if a specific formula or algorithm is followed and executed perfectly, the outcome is unpredictable (148). There are many interacting biopsychosocial factors that can influence the development of a child. Another analogy is soccer or football, where the success of a team is contingent upon and the interaction between; the players, the manager, the back office staff, the quality of the pitch, the weather, the nerves of the star players, and the noise of the crowd (150). Thus, in soccer, a perfectly designed and executed game plan can still result in losing a match because the outcome is influenced by a vast interconnected web of variables. Similarly, the provision of an exercise program for an individual with RCRSP is complex, often unpredictable in terms of individual outcomes, and involves many individual components that can influence clinical outcomes. This is demonstrated when assessing the individual outcomes of people who have engaged with a standardised exercise program, with some improving dramatically, some experiencing a worsening of symptoms, and others unchanged (151). The success of an exercise program may be conditional upon a number of interacting parts that can combine to influence the outcome. This might include, but is not limited to, the individual patient, the therapist, the patient-therapist relationship, the front desk, the noise in the clinic, the exercise equipment chosen, cultural attitudes towards exercise, and so on, almost indefinitely. Small changes in a positive or negative direction in any of these variables can dramatically influence a clinical outcome.

Acknowledging complexity means appreciating context. If exercise therapy is a complex treatment it means it can, in principle, be influenced by the relational and sociocultural environment in which it is delivered (141). This evades the tightly controlled conditions often demanded by RCTs (141). Critical realism encourages the analysis and critical examination of how and why a

phenomenon occurred, exploration of the context that triggered or inhibited the identified causal mechanisms, and can enable identification of treatment-mechanism-context relationships that are associated with certain outcomes (141, 152). Critical realism acknowledges the complexity of the real world, where RCRSP and exercise therapy most certainly inhabit, and emphasises that this complexity and contextuality can profoundly alter individual outcomes to a particular health intervention, such as exercise therapy. Overall, critical realism is a critical research method, seeking to challenge and explore established norms and structures by going beyond surface level observation.

Complexity science also compels us to see the whole. It is anti-reductionist. Conversely, conventional health science promotes the pursuit of predictable and consistent solutions to health problems (153). This is often executed by linear monocausal thinking and experimentation, in which a singular cause to explain the onset of health problems and the effectiveness of their treatments is pursued. However, this philosophy of reductionism, which controls for context, fails to capture the messy and chaotic reality of the events that take place in our world, and thus its utility for understanding complex phenomenon (e.g. pain) (154) and treatments (e.g. exercise therapy for RCRSP) is contested. The parable of the blind people and the elephant, a tale famous in Indian folklore, poetically captures the limitations of viewing the whole through a reductionist and limited lens. The story goes that six blind people wanted to know what an elephant looked like simply by using their sense of touch. Each of the people touched a different part of the elephant and came to dramatically different conclusions on what the elephant looked like. One touched the tusk and thought it must look like a spear. Another touched the trunk and thought it must be snake like. Another touched the tail and thought it must resemble a rope (155). And on it went. The blind people could not reach consensus on the what the elephant must look like because they were each examining a tiny fraction of the elephant and neglecting the whole. If we apply the logic of this parable to health science, and especially exercise for RCRSP, and we continue to neglect the influence of context on clinical outcomes, we may fall deeper and deeper into a reductionist and siloed hole and risk never seeing the whole.

CHAPTER 2: Research objective, questions, gaps, and methods

2.1 RESEARCH OBJECTIVES

The primary objective of this research program is to elucidate and synthesise the proposed mechanisms of benefit of exercise for the management of RCRSP. This objective will be achieved by conducting a scoping review of the literature (Chapter 4), a cross-sectional survey of physiotherapists (Chapter 5), and a qualitative investigation exploring the lived experience of individuals with RCRSP (Chapter 6). Furthermore, the clinical context that influences outcomes of individuals engaging with an exercise program will also be explored in Chapter 6. A secondary objective of this thesis is to amalgamate knowledge acquired during this research program regarding causal mechanisms with the existing shoulder literature to construct a user manual of exercise therapy for RCRSP for the time limited clinician (Chapter 7).

2.2 RESEARCH QUESTIONS

The following questions guided the research conducted within this thesis:

1. What are the causal mechanisms proposed in clinical research to explain the beneficial effects of exercise therapy for individuals with RCRSP?
2. How and why do registered physiotherapists believe exercise therapy helps their patients with RCRSP?
3. What explanations do individuals with lived experience of RCRSP provide for a clinical improvement through engaging with an exercise program?
4. Are there any clinical conditions or contexts that facilitate or inhibit a positive experience with exercise therapy according to individuals with RCRSP?
5. How should clinicians use knowledge of causal mechanisms and their associated context in their practice?
6. Is it the specific targets of exercise therapy that helps people recover from RCRSP, or are there other explanations?

2.3 RESEARCH GAPS

The causal mechanisms underpinning the beneficial effect of exercise for RCRSP is uncertain and under-researched. There is no systematic or scoping review of the possible causal mechanisms of exercise for RCRSP. There are no surveys of physiotherapists exploring their beliefs regarding how and why exercise may be of benefit for their patients with RCRSP. There are no qualitative studies specifically investigating the lived experience of individuals with RCRSP in

relation to their perceptions about how engaging with an exercise program influenced their shoulder pain and function. There are no studies in the shoulder literature which specifically explore the relationship between exercise therapy-context-mechanism-outcome in individuals with RCRSP. Furthermore, there is limited research critically examining the role of exercise therapy for managing individuals with RCRSP, resulting in exercise appearing to be held to a lesser standard of critique compared to other physiotherapy treatments, such as manual therapy and acupuncture. There is a lack of causal knowledge regarding exercise for RCRSP, making it a challenge for researchers and clinicians to provide accurate explanations and education to participants and patients about why they are being prescribed an exercise program and how it is expected to help them. Moreover, there is insufficient knowledge about plausible treatment targets for clinicians, which can lead to clinicians focusing on treatment targets that aren't causally associated with a reduction in shoulder pain or an improvement in shoulder function, resulting in possible sub-optimal outcomes and overtreatment. A comprehensive research program, including a triumvirate of stakeholders, to identify and synthesise the prevailing perceptions about the causal mechanisms of exercise for treating RCRSP appears warranted and appropriate. Furthermore, a robust critical examination of the absolute benefit and basic causal claim of exercise therapy for RCRSP may also be of value. To address these gaps, a mixed methods research program was devised and executed, under an overarching critical realist philosophy of science (see Chapter 1 for explanation of critical realism).

2.4 RESEARCH METHODS

The critical realist approach to research, as outlined in Chapter 1, is flexible and amenable to quantitative, qualitative and mixed methods designs and broadly supports research endeavours that seek causal explanations (141, 142). The primary aim of this research program is to elucidate, synthesise and examine the mechanisms that underpin the effectiveness of an exercise program for individuals with RCRSP, and explore contexts that may support or inhibit the activation of identified causal mechanisms. This necessitates a mixed methods research design, utilising both quantitative, qualitative, and critical methods in order to satisfactorily achieve its aim.

First, a scoping review of clinical trials and a survey of practising physiotherapists will rely on traditional quantitative research methods to elucidate common causal explanations of the beneficial effects of exercise for RCRSP. Next, a qualitative study using semi-structured interviews guided by a critical realist philosophical approach, will similarly seek to identify the causal mechanisms of exercise for RCRSP. This qualitative study will also explore the contextual features that may have triggered or inhibited identified causal mechanisms.

A critical review will then explore the value of exercise therapy for managing RCRSP, by critically examining its overall effect, how and why it may be of benefit to individuals with RCRSP, and the barriers and enablers to successful exercise-led rehabilitation.

Finally, a narrative review will explore the causal claim of exercise therapy for RCRSP through the Bradford Hill viewpoints. The Bradford Hill viewpoints are an antecedent to the modern-day EBM+ movement and considers mechanistic evidence, probabilistic evidence, and the stability of effects across different background conditions when exploring the causal claim of an intervention.

2.5 OUTLINE OF THESIS CHAPTERS

This thesis consists of nine chapters, of which the manuscripts contained within chapters three through eight have been published or are currently under review (at time of submission) for publication in peer-reviewed journals. This is illustrated in Figure 4.

Chapter one introduces RCRSP, exercise therapy and outlines the importance of causal explanation in health science research and practice.

Chapter two presents the research objective, questions, gaps, and methods this research program employs.

Chapter three presents an editorial that challenges the prevailing view of how and why exercise therapy may help individuals with RCRSP. The manuscript within this chapter has been published in the *Journal of Orthopaedic and Sports Physical Therapy*.

Chapter four is a scoping review that identifies and synthesises common causal mechanisms proffered in clinical trials to explain the beneficial effect of exercise therapy for RCRSP. The manuscript within this chapter has been published in *Musculoskeletal Science and Practice*.

Chapter five is a cross-sectional survey of physiotherapists. The survey explores the beliefs and perceptions of practicing physiotherapists about how and why exercise is effective for individuals with RCRSP. The manuscript within this chapter has been published in *Musculoskeletal Care*.

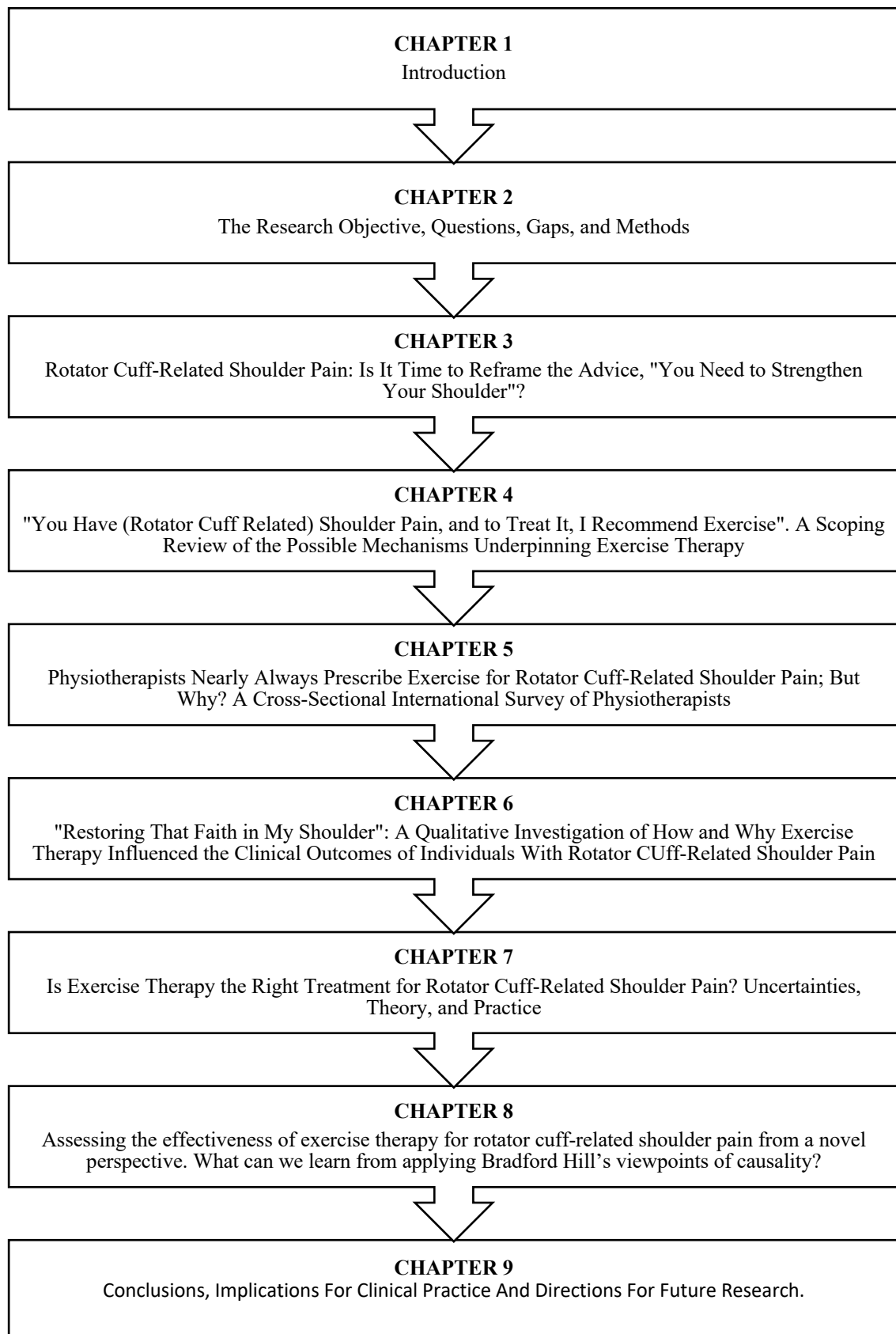
Chapter six is a qualitative investigation using semi-structured interviews to explore the beliefs of individuals with lived experience of RCRSP about how they perceive exercise to have helped, or hindered, their pain. This study is unique, in that it also explores the clinical conditions that may have facilitated or inhibited the activation of proposed causal mechanisms. The manuscript within this chapter has been published in *Physical Therapy and Rehabilitation Journal*.

Chapter seven is a critical review of exercise therapy for RCRSP. The study aims to bring together knowledge gained from this research program with the existing shoulder literature to provide suggestions for clinicians about how to use exercise therapy in a way that is concordant with current science. The manuscript within this chapter has been published in *Musculoskeletal Care*.

Chapter eight is a novel narrative review that uses the Bradford Hill viewpoints of causality to examine the literature regarding the effectiveness of exercise therapy for RCRSP. The manuscript within this chapter is currently under review at *Shoulder and Elbow*.

Chapter nine includes a discussion on the key findings of the thesis and conclusions made. The strengths and limitations of the research, its implications for clinical practice and possible directions for future research are discussed in this chapter.

Figure 4: Flow of thesis chapters



CHAPTER 3: Rotator cuff-related shoulder pain: Is it time to re-frame the advice, “You need to strengthen your shoulder”?

3.1 PREFACE

This chapter features an editorial published in the *Journal of Orthopaedic and Sports Physical Therapy* and represents a succinct introductory overview of the shoulder literature as it pertains to the research question: “how and why is exercise effective for RCRSP”? Subsequent chapters (4-8) comprehensively build on this preliminary discussion.

The following article is presented as published in *Journal of Orthopaedic and Sports Physical Therapy* (see appendix 3.1).

Reproduced with permission from Powell JK, Lewis JS. Rotator Cuff-Related Shoulder Pain: Is It Time to Reframe the Advice, "You Need to Strengthen Your Shoulder"? J Orthop Sports Phys Ther. 2021;51(4):156-8. DOI: [10.2519/jospt.2021.10199](https://doi.org/10.2519/jospt.2021.10199). ©Journal of Orthopaedic and Sports Physical Therapy®, Inc.

3.2 SYNOPSIS

Progressive resistance exercise, in isolation or in combination with other non-invasive therapies, such as therapeutic touch is the first-line approach to managing non-traumatic rotator cuff related shoulder pain (RCRSP). Resistance exercise may be effective for people with RCRSP secondary to improving mechanical features of the shoulder, including strength, kinematics and muscle timing and activation. However, strength gains are often small and clinically unimportant when measured during clinical trials. In this viewpoint we argue clinicians should (i) continue to prescribe resistance exercise when managing RCRSP and (ii) embrace the broad biological mechanisms underpinning why resistance exercise is effective. Any benefit is governed by more than simple mechanical changes. The clinical message must go beyond: the patient's weak, deconditioned or frail shoulder is the basis of their pain, and to fix the problem, all they need to do is 'get strong'.

Key words:

Rotator cuff, scapula, shoulder, therapeutic exercise

3.3 BACKGROUND

Over the past two decades, evidence supporting non-surgical management of non-traumatic rotator cuff related shoulder pain (RCRSP) has grown. The most recent clinical practice guideline recommends advice, education and non-surgical management as the primary approach to managing RCRSP (35).

Non-traumatic RCRSP is pain and dysfunction of the shoulder, commonly observed during shoulder elevation and external rotation, for which other conditions have been excluded (42). Terms such as RCRSP and subacromial shoulder pain may be more appropriate than traditional pathoanatomic diagnoses of the rotator cuff and related structures (including subacromial bursitis, rotator cuff tendinopathy, partial thickness and non-traumatic full thickness rotator cuff tears) as it is difficult to identify a specific structure or pathology as the primary contributor to an individual's shoulder pain (42). The clinical presentation of RCRSP is always influenced by individual cognitions, emotions, behaviours and sociocultural factors that further complicate the pursuit of a single structure that causes shoulder pain.

Quality non-surgical management of RCRSP comprises a graduated program of progressive resistance exercise (against gravity and with external load) and occasionally in conjunction with stretching and mobility exercises of the shoulder structures and thoracic spine (74). The pendulum swing towards non-surgical management is underscored by research demonstrating that subacromial decompression surgery, once the gold standard intervention for RCRSP, does not confer superior outcomes to non-surgical approaches or placebo (35).

Resistance exercise, and strength training more broadly, is riding a wave of popularity for managing various non-traumatic musculoskeletal pain presentations and should be considered a veritable polypill with multi-system benefits. While exercise therapy has emerged as the primary intervention for managing RCRSP, there is uncertainty regarding which exercise approach is best, and the absolute benefit of exercise compared to non-exercise interventions (156).

This Viewpoint explores the use of resistance exercise for managing non-traumatic RCRSP and examines how resistance exercise may provide clinical benefit for patients with shoulder pain.

3.4 WHY DO CLINICIANS USE RESISTANCE EXERCISE FOR RCRSP?

Clinical reasoning in physical therapy is traditionally embedded within a biomedical framework: pursue a measurable physical impairment and, if one is identified, apply an appropriate intervention to correct the impairment. This model of clinical reasoning works under the guise that pain and dysfunction arise due to observable deficits in physical properties of the body.

For RCRSP, resistance exercise is typically prescribed to strengthen a weak shoulder. Resistance exercise may also be prescribed with the intent of improving shoulder girdle kinematics or timing and activation of peri-shoulder musculature. The implication is an assumed isomorphic relationship between shoulder strength, function and pain: increase strength to decrease pain and increase function. While biologically plausible, the reality is less certain.

3.5 MOVEMENT AND STRENGTH DEFICITS CHARACTERISE RCRSP – CAN EXERCISE HELP?

People with RCRSP have changes in movement and strength that can be measured. Some people with RCRSP have altered scapulothoracic kinematics (157), however, there is widespread inconsistency in the type of alterations observed. Glenohumeral and scapulothoracic muscle timing and activity, often measured by electromyography (EMG), varies in people with RCRSP compared to people without symptoms (158). People with RCRSP may have deficits in external rotation and abduction strength of up to 43% when compared to an asymptomatic population (159). Strength deficits have also been observed in the scapulothoracic joint muscles, although not as profound as the glenohumeral joint muscles (160).

Does improving shoulder mechanics and strength always improve pain and function? We suggest not. Strength gains with a typical rehabilitation regimen for RCRSP are moderate at best (161, 162) and often clinically unimportant (104, 163, 164). Scapular kinematics (scapular dyskinesis) need not be normalized for pain and function to improve (165), and it is unclear whether scapula-focused exercise interventions are superior to general shoulder strengthening. It would be clinically impossible to prescribe an exercise that targeted the scapular muscles at the expense of the rotator cuff and vice versa. Restoring shoulder muscle timing and activity appears superfluous to overall improvement of pain and function in people with RCRSP.

Despite the limited improvements in mechanical measures of the shoulder, there are often substantial improvements in pain and function in trials that use resistance exercise for rehabilitation

(104, 164, 166). We suggest these clinical phenomena challenge the relationship between shoulder strength, function and pain.

3.6 WHY THE LIMITED INCREASES IN STRENGTH? UNDERLOADED EXERCISE AND EXCESSIVELY CAUTIOUS THERAPISTS?

A frequent critique of clinical trials using resistance exercise is they are underloaded and overly cautious. It is possible that a more stringent application of strength and conditioning principles such as intensity, volume and duration of training, could elicit a more dramatic increase in shoulder strength. However, it is unclear if this would translate into similar improvements in shoulder pain and function.

Trials that purport to employ high load resistance exercise often report underwhelming improvements in strength (164, 166), and it is unclear whether high dose (high load or high volume) resistance exercise is clinically superior to low dose (low load or low volume) resistance exercise for RCRSP (106).

3.7 HAVE CLINICIANS BEEN SEDUCED BY THE HYPE OF STRENGTHENING?

Manual therapy, once a mainstay of non-surgical management for RCRSP, has not stood the test of rigorous trials. Many proponents of ‘you only need to get strong’ may suffer a similar demise, as the next generation treatment approach—strength training—has not yet passed muster through rigorous clinical trials. Perhaps informing a person with RCRSP “you are weak—you simply need to get stronger” may be as counterproductive as telling the person “you have poor posture, and it needs to be improved”? It is essential that clinical trials test modern strength and conditioning principles to establish the relationship between strength, function and shoulder pain.

3.8 IS THERE MORE TO RESISTANCE EXERCISE THAN MEETS THE EYE FOR RCRSP?

Emerging evidence suggests non-traumatic RCRSP is a multidimensional condition, associated with several biopsychosocial sub-domains. The severity of shoulder pain and level of shoulder function do not appear strongly associated with shoulder strength (160, 167). There is more to RCRSP than simple strength, and the same could be said for resistance exercise. Exercise (including resistance exercise) may have a hypoalgesic effect, improve health-related quality of life,

improve pain-related self-efficacy and confidence, influence systemic inflammatory markers, mark time while nature takes its course, provide a distraction, and potentially lead to a re-evaluation of pain. Clinicians might consider these factors when prescribing resistance exercise as part of a rehabilitation regimen for a person with non-traumatic RCRSP.

3.9 INTEGRATING RESISTANCE EXERCISE INTO A MODERN UNDERSTANDING OF RCRSP

A modern interpretation of pain emphasizes a multidimensional experience, far more than a simple linear read-out of sensory input from the peripheral tissue. Perhaps clinicians could apply this logic to mechanical measures of the shoulder? Variables such as shoulder strength and scapulothoracic kinematics may be relevant to non-traumatic RCRSP. However, devoting an inequitable amount of time and attention to these factors may be a naïve and inadequate approach.

3.10 SUMMARY

We are concerned that resistance exercise for managing RCRSP is at risk of becoming a blunt instrument—used without critical thought in a classic recipe-based approach. Awkwardly, this is an illustration of the type of biomedical clinical reasoning the profession of physical therapy has spent the past two decades (or more) trying to avoid. Resistance exercise has a place in a quality rehabilitation program for people with RCRSP—to improve how the shoulder functions, increase confidence to use the shoulder, and help reduce pain. Resistance exercise is an important and cost-effective intervention and physical therapists should not be afraid to use it. We argue there is nuance to consider when using resistance exercise for rehabilitation.

3.11 KEY POINTS

- People with RCRSP often have demonstrable variations in kinematic, strength, and muscle timing and activation profiles compared to people without RCRSP.
- Resistance exercise can improve pain and function in people with non-traumatic RCRSP without a significant normalization of shoulder mechanical factors; including strength, scapulothoracic kinematics and muscle timing and activation.
- Non-traumatic RCRSP is a multidimensional condition that requires a multidimensional approach.
- The rationale for prescribing resistance exercise for non-traumatic RCRSP needs to be reframed as a multidimensional intervention that can confer benefit by numerous interrelated

biopsychosocial processes, not simply by increasing shoulder strength or improving shoulder mechanics.

- Future research should study the ideal dose of resistance exercise, considering training variables such as intensity, volume and duration, for managing non-traumatic RCRSP.

CHAPTER 4: “You have (rotator cuff related) shoulder pain, and to treat it, I recommend exercise”. A scoping review of the possible mechanisms underpinning exercise therapy

4.1 PREFACE

Chapter 3 presented a critical introduction to the question “how and why is exercise effective for RCRSP?”. Chapter 4 builds on this with a scoping review of the causal mechanisms proposed in the shoulder literature. The limited evidence-base investigating the causal mechanisms of exercise for RCRSP necessitated a scoping review design, which facilitated a comprehensive mapping of the literature. The aim of this scoping review was to elucidate and synthesise commonly proposed causal explanations for the beneficial effects of exercise for RCRSP in published randomised clinical trials. This chapter represents an important first step in developing an understanding of the prevailing view of clinical researchers about how and why exercise therapy is believed to help individuals with RCRSP.

The following manuscript was published in *Musculoskeletal Science and Practice* (see appendix 4.1).

Powell JK, Schram B, Lewis J, Hing W. “You have (rotator cuff related) shoulder pain, and to treat it, I recommend exercise.” A scoping review of the possible mechanisms underpinning exercise therapy. *Musculoskeletal Science and Practice*. 2022;62. DOI: [10.1016/j.msksp.2022.102646](https://doi.org/10.1016/j.msksp.2022.102646).

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4.2 ABSTRACT

Background

Exercise is considered to be both essential and at the forefront of the management of rotator cuff-related shoulder pain (RCRSP). Despite this, many fail to substantially improve with exercise-based treatment. Hence, expanding the current knowledge about the possible mechanisms of exercise for RCRSP is critical.

Objective

To synthesise the range of mechanisms proposed for exercise in people with RCRSP.

Design

Scoping review.

Methods

A systematic search of the Physiotherapy Evidence Database (PEDro) was conducted from inception to July 3, 2022. Two reviewers conducted the search and screening process and one reviewer extracted the data from each study. Randomised clinical trials using exercise for the management of RCRSP of any duration were included. The PEDro search terms used were “fitness training”, “strength training”, “stretching, mobilisation, manipulation, massage”, “upper arm, shoulder, or shoulder girdle”, “pain”, and “musculoskeletal”. Data were analysed using quantitative and qualitative approaches.

Results

626 studies were identified and 110 were included in the review. Thirty-two unique mechanisms of exercise were suggested by clinical trialists, from which 4 themes emerged: 1) neuromuscular 2) tissue factors 3) neuro-endocrine-immune 4) psychological. Neuromuscular mechanisms were proposed most often (n= 156, 77%). Overall, biomedical mechanisms of exercise were proposed in 95% of cases.

Conclusions

The causal explanation for the beneficial effect of exercise for RCRSP in clinical research is dominated by biomedical mechanisms, despite a lack of supporting evidence. Future research should consider testing the mechanisms identified in this review using mediation analysis to progress knowledge on how exercise might work for RCRSP.

Highlights

- This study explored commonly proposed mechanisms of exercise for RCRSP.
- Muscle strength and motor control were the most commonly proposed mechanisms.
- Psychosocial mechanisms were scarcely proposed.
- Biomedical mechanisms accounted for 95% of proposed mechanisms of exercise.
- Identified mechanisms of exercise should be tested as possible mediators of recovery.

4.3 INTRODUCTION

The scientific method is possibly one of humanity's greatest triumphs. According to the philosopher Karl Popper, the aim of science is "to find satisfactory explanations" of worldly phenomena (109). In health science, satisfactory explanations often involve identification of possible causal mechanisms (168), for example; *how* is a particular disease or injury caused or *why* is a particular intervention effective (or not)? Asking these questions and testing hypotheses is at the heart of the scientific process. The importance of this process is acknowledged by The Consolidated Standards of Reporting Trials (CONSORT), which recommends authors consider possible mechanisms and explanations for how their interventions might work (169). A mechanism, in this sense, is an "*epistemic model that enables the explanation of how phenomena are causally brought about*" (114).

Rotator cuff-related shoulder pain (RCRSP) is an overarching clinical term proffered to replace potentially unsound pathoanatomical explanations for a patient's symptoms such as subacromial and posterosuperior impingement syndrome, bursitis, tendinitis, partial and full thickness rotator cuff tendon tears (42). RCRSP is ascribed to the presentation of shoulder pain and or weakness that most commonly involves shoulder elevation and external rotation where other conditions have been excluded. It is itself a hypothesis based upon information gained during the patient interview and clinical examination (42, 170). The emergence of RCRSP is likely a complex and truly biopsychosocial process that may differ from person to person (171) but it does appear closely related to alterations in shoulder loading (172-174). RCRSP is prevalent in the community (8), more so with advancing age (175), and can significantly impact work (10), recreation, sleep, and overall quality of life (11, 176). A less-than-optimal response to medical, non-surgical, and surgical interventions is common with approximately half experiencing continued symptoms for up to 2 years (177), highlighting the necessity for ongoing research. Currently all clinical practice guidelines recommend exercise for the management of RCRSP (76). This is despite exercise

consistently demonstrating modest clinical effects (156, 178), the enduring uncertainty of how and why exercise may be of benefit and the fact many who partake in a rehabilitative exercise program for RCRSP fail to substantially improve (179). Complicating interpretation of exercise trials for RCRSP is the variation in types of exercise used, and the consistently poor reporting of how the exercises are performed, making replication and assessment of clinical implications at best, challenging (94, 95, 107). Moreover, recent evidence has called into question the validity of a number of mechanisms that have traditionally been thought responsible for a successful recovery from RCRSP, such as the need for surgical rectification of ‘acromial impingement’ (33, 34), and the clinical need to significantly improve shoulder strength (179) and optimise scapula kinematics with an exercise program (180). While exercise appears to be a sensible first-line intervention for managing RCRSP, unanswered questions remain regarding its possible mechanism of effect.

One approach for progressing the understanding of exercise for RCRSP is to investigate proposed mechanisms of benefit of exercise in clinical research (181). There is a relationship between the clinical rationale for a particular exercise approach and the hypothetical causal mechanism(s) thought to lead to a particular outcome (e.g., reduced pain, increased function, or reduced disability) (181). In musculoskeletal physiotherapy it is common to target intermediary factors with treatments that are thought to causally produce a particular outcome (123). For example, resistance exercise (treatment) could plausibly be used to increase shoulder strength (intermediary) for people with RCRSP, which would then causally lead to reduced shoulder disability (outcome). In this example, weakness is the hypothesised causal mechanism for the symptoms, and increased shoulder strength is the proposed *causal mechanism* for the effect of the treatment (resistance exercise).

Identification and synthesis of suggested mechanisms of exercise in the management of RCRSP may facilitate future research, where the hypothesised mechanisms may be tested. This may improve our understanding of the biopsychosocial basis for RCRSP and facilitate improved management. The aim of this scoping review was to identify and synthesise the suggested mechanisms of benefit of exercise for managing RCRSP as articulated in randomised clinical trials. To the best of the authors’ knowledge, no such scoping review of proposed mechanisms has been previously conducted.

4.4 METHODS

4.4.1 *Data sources and explanation of method*

The protocol for this review was preregistered on the Open Science Framework on June 23, 2021 (<https://osf.io/j3y4x/>). This review used a search strategy previously published by Cashin et al 2020 and Wun et al 2021 (181, 182). These two reviews demonstrate the adequacy of a search strategy exclusively using the Physiotherapy Evidence Database (PEDro). PEDro is considered the most complete electronic database of randomised controlled trials (RCTs), indexing up to 99% of RCTs that use interventions within the scope of practice of physiotherapists (182, 183). The current review explored mechanisms of exercise for RCRSP, and, as exercise is the most common intervention used by physiotherapists for managing people with RCRSP (94-96), it was inferred that a comprehensive search of the PEDro database would produce a satisfactory number of relevant RCTs to fulfil the aim of this review.

4.4.2 *Study selection*

The PEDro electronic database was searched from inception to July 3, 2022. We used PEDro predefined search terms “fitness training”, “strength training”, “stretching, mobilization, manipulation, massage” for the therapy field, “upper arm, shoulder or shoulder girdle” for body part field, “pain” for problem field, “musculoskeletal” for subdiscipline field, and “clinical trial” for method field. More information on PEDro codes can be found at <https://pedro.org.au/english/learn/indexing-criteria-and-codes/#part-2>. The condition of interest was RCRSP (Table 2) of any duration. Eligible studies must have included exercise in at least one arm of the clinical trial but we did not specify that exercise must be used in isolation. However, we did exclude studies in cases where exercise was only used post-surgically and where exercise was provided in conjunction with a corticosteroid injection (Table 4). In summary, a study was included if it was a clinical trial, the condition of interest was RCRSP (Table 1), exercise was used in at least one arm of the trial (Table 3) and did not feature any of the exclusion criteria (Table 4).

Table 2: Rotator cuff-related shoulder pain

Subacromial impingement	Rotator cuff disease
Shoulder impingement	Rotator cuff syndrome
Subacromial pain syndrome	Rotator cuff tendinopathy/tendonitis/tendinosis
Subacromial shoulder pain	Shoulder pain during arm elevation for which other conditions have been excluded
Rotator cuff tear (partial and full thickness)	

Table 3: Exercise intervention categories

Resistance exercise (against gravity, external load, and bodyweight)	Neurodynamic exercise
Mobility exercise (range of motion exercise of glenohumeral, scapulothoracic joint and thoracic spine)	Plyometric exercise
Stretching exercise (of muscle, tendon, capsule)	Proprioceptive exercise
Motor control exercise (including scapular stability/control, humeral head centring, and motor learning exercise)	Aerobic exercise
Postural exercise	Other active movement approaches

Table 4: Exclusion criteria

Frozen shoulder/adhesive capsulitis	Rheumatological disorders
Full thickness rotator cuff tears affecting both the anterior and posterior rotator cuff	Neoplasm
Shoulder instability	Myofascial pain of the upper arm and neck
Osteoarthritis	Post-surgical rehabilitation
Calcific tendinopathy	Post-injection rehabilitation
Fracture	Cervicogenic / thoracic spine / visceral referred shoulder pain
Cervical radiculopathy	Trials published in language other than English for which there is no translation
Neurological disorders	Long COVID-19
Preliminary studies	Fibromyalgia

One team member (JP) independently screened the titles and abstracts of records captured by the systematic search strategy. A second team member (BS) independently repeated this step to ratify the process. Any disagreements were rectified by discussion. Full texts were retrieved for all eligible studies, in which case the study was again scrutinised to confirm eligibility for inclusion.

4.4.3 Data extraction

A custom Microsoft™ Word spreadsheet for data extraction was created using an iterative process. For each eligible study we extracted information related to population characteristics, specifics of exercise intervention (including dose, type and equipment used), the proposed mechanism of benefit or clinical rationale of exercise intervention, outcome measures, diagnostic label used to describe RCRSP and methodological quality in the form of PEDro score. Exercise interventions from eligible studies were organised into general categories (Table 3). An exercise intervention was recorded as either multimodal or unimodal. Multimodal was defined as comprising two or more of the exercise categories whereas unimodal included only one. If an exercise

intervention was used in conjunction with another physiotherapy modality, such as manual therapy, the adjunct modality was recorded, and the exercise program was extracted in detail.

The introduction and discussion sections of eligible studies were systematically analysed for a causal explanation of the potential beneficial effect of exercise for RCRSP (184). When a causal explanation was identified it was extracted, verbatim, and populated into our data extraction spreadsheet. In the event a causal explanation for the beneficial effect of exercise was not provided in a study, this was recorded as *not specified*. If studies provided multiple mechanisms, they were all recorded.

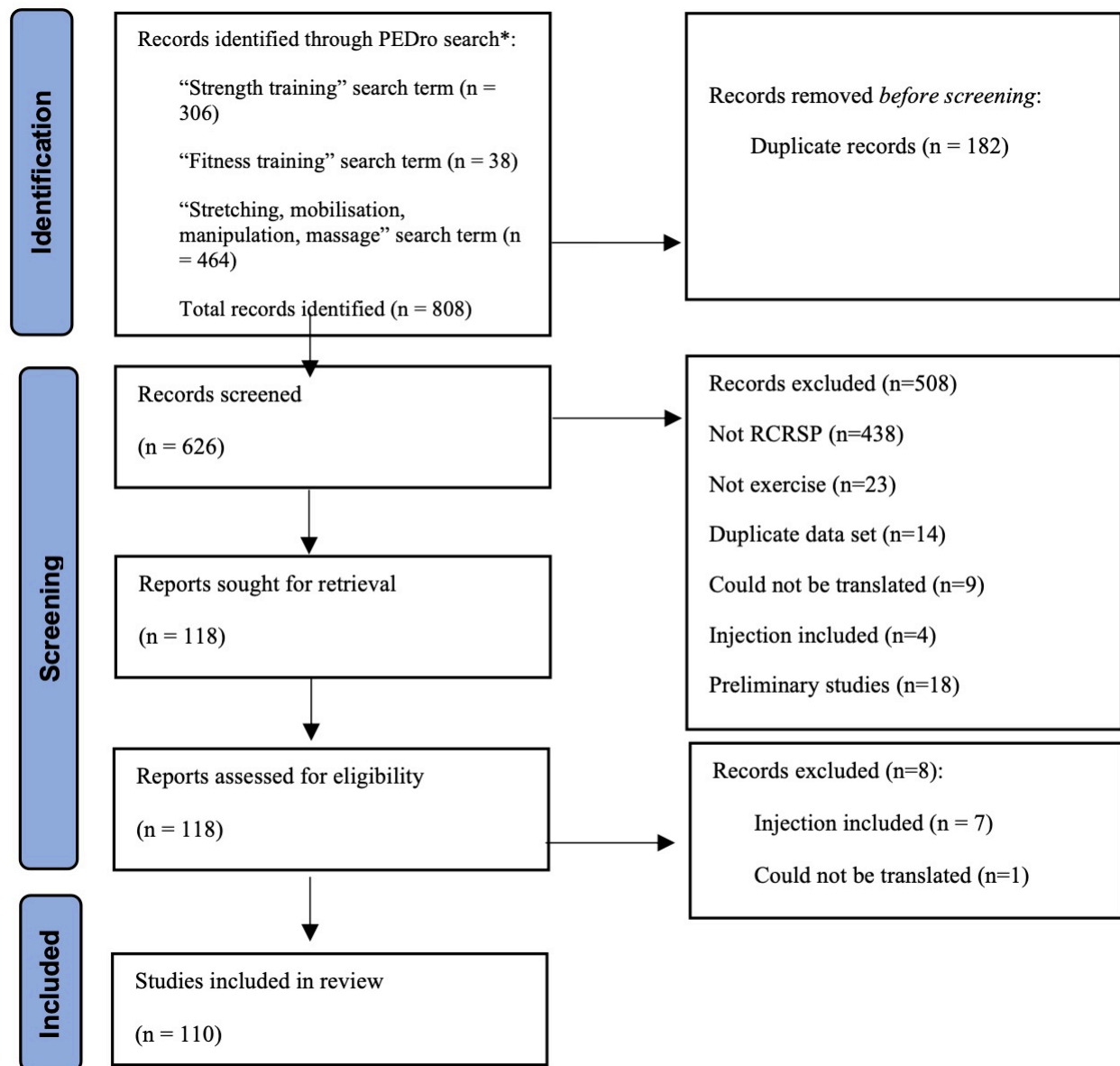
4.4.4 Data analysis

Data analysis involved quantitative and qualitative approaches. The number of unique mechanisms proposed were counted, in addition to how often each mechanism was proposed. This process was replicated for the exercise interventions utilised in each eligible study. The unique diagnostic label used to describe RCRSP was also counted. Qualitative synthesis involved grouping the raw mechanisms proposed by clinical trialists into themes. Finally, the themes were dichotomised into biomedical or psychosocial constructs.

4.5 RESULTS

After removing duplicates, the literature search generated a total of 626 abstracts. A total of 508 studies were excluded after screening the titles and abstracts. Subsequently, 118 full texts were obtained. After the selection criteria was applied again a further eight studies were removed, leaving 110 studies included in the review (Figure 5).

Figure 5: PRISMA flow diagram showing the search and screening process (185)



Legend: RCRSP (rotator cuff related shoulder pain)

The included trials covered four decades of research dating from 1998 to 2022. Data extraction of the included studies identified 32 raw mechanisms of exercise for the management of RCRSP. The median number of mechanisms proposed per trial was two (range 0-12). Of the 32 raw mechanisms, motor control (n=47) and muscle strength (n=43) were the most commonly proposed. Five mechanisms (muscle strength, motor control, acromiohumeral distance, mobility, soft tissue length/tension) accounted for 71% of all mechanisms.

The 32 unique mechanisms were organised into four themes: 1) neuromuscular, 2) tissue factors, 3) neuro-endocrine-immune, and 4) psychological (see Table 5 and Figure 6). In total, 76 (69%) studies proposed a mechanism of exercise and 34 (31%) did not specify a mechanism.

Neuromuscular mechanisms were proposed most often (n=156 (77%)). All other themes were proposed at a similar rate, with psychological mechanisms being proposed the least (n=10 (5%)). When dichotomised into biomedical (neuromuscular, tissue factors, and neuro-endocrine-immune themes) and psychological mechanisms, biomedical mechanisms were proposed 95% (n=193) of the time. When a psychological mechanism was proposed, it was in conjunction with a biomedical mechanism. Seventy percent of all psychological mechanisms were proposed between 2017-2022.

Before 2007, 30% of studies did not provide an explanation for the proposed mechanism of effect of exercise for RCRSP. From 2007-2011, 28% of studies did not provide an explanation. From 2012-2016, 30% of studies did not provide an explanation. From 2017-2022, 33% of studies did not provide an explanation.

Specific examples of proposed mechanisms of exercise for RCRSP for each identified theme are listed below for more information on specific mechanisms).

4.5.1 Neuromuscular

"The aim of the training program in the present study was to **strengthen the musculature of the rotator cuff**, which is likely to have been one of the factors that led to the improvement of pain" (164).

4.5.2 Tissue factors

"Possible mechanisms for explaining treatment effects are improved **circulation** in the affected structures" (186).

4.5.3 Neuro-endocrine-immune

"Possible mechanisms for explaining treatment effects are pain modulation by activating the **gate control system** in the posterior horn of the spinal cord" (186).

4.5.4 Psychological

"The mechanisms are probably several, ranging from effects on a cellular level to cognitive functions such as **coping** and **self-efficacy**" (186).

Nine different exercise types were tested for the management of RCRSP (Table 6). Resistance exercise was the most prescribed exercise intervention and was utilised as part of an exercise package in 93% of included studies. The next most common exercise interventions were stretching exercise (62%), mobility exercise (55%), and motor control exercise (40%). Twenty-seven different exercise packages (one or multiple exercise interventions) were identified for the

management of RCRSP (Table 6). The most frequently used exercise package was a multimodal program of resistance exercise, stretching exercise and mobility exercise (n=27) (187-209). Multimodal exercise programs were used five times more (n=109) than unimodal programs (n=21). Exercise was used as a stand-alone intervention in at least one arm of 51% of included trials (n=56). When exercise was not stand-alone it was most often employed in conjunction with electrotherapeutic modalities (e.g. TENS, ultrasound and electromagnetic therapy) (n=26), hot or cold therapy (n=20) and manual therapy (n=19).

Subacromial/shoulder impingement syndrome was the most used diagnostic label, accounting for 58% (n=64) of included studies, and was used 4 times more frequently than the second most common label, rotator cuff tendinopathy/tendonitis. A total of 84% of studies that propose an increase in acromiohumeral distance to be a possible mechanism of benefit of exercise for RCRSP used the diagnostic label subacromial/shoulder impingement syndrome.

The average PEDro score of all included studies was 6.2. Where a mechanism or clinical rationale was proposed the average PEDro score was 6.3, and where it wasn't the average score was 6.

Table 5: Summary of mechanisms and themes suggested in included studies

Theme (number of times suggested) and %	Neuromuscular (n=156) 77%	Tissue factors (n=23) 11%	Neuro – endocrine – immune (n=14) 7%	Psychological (n=10) 5%
Mechanism (number of times suggested)	Motor control (n=47)	Muscle and tendon properties (n=6)	Inflammation (n=5)	Self-efficacy (n=2)
	Muscle strength (n=43)	Tendon remodelling (n=6)	PNS/CNS sensitivity (n=3)	Coping with pain (n=2)
	Mobility / range of motion (n=20)	Blood flow (n=3)	Exercise-induced hypoalgesia (n=2)	Reassurance (n=1)
	Acromiohumeral distance (n=19)	Oxygen availability (n=3)	Gate control (n=1)	Fear avoidance (n=1)
	Soft tissue length/tension (n=15)	Angiogenesis (n=2)	Hormonal (n=1)	Pain catastrophising (n=1)
	Proprioception (n=4)	Tendon homeostasis (n=1)	Endogenous neuropeptides (n=1)	Perceived disability (n=1)
	Neuromuscular activity (n=3)	Collagen synthesis (n=1)	Biochemical (n=1)	Graded exposure (n=1)
	Posture (n=3)	Muscle and tendon architecture (n=1)		Motivation (n=1)
	Muscle endurance (n=2)			

Figure 6: Proposed mechanisms of exercise for RCRSP organised into themes

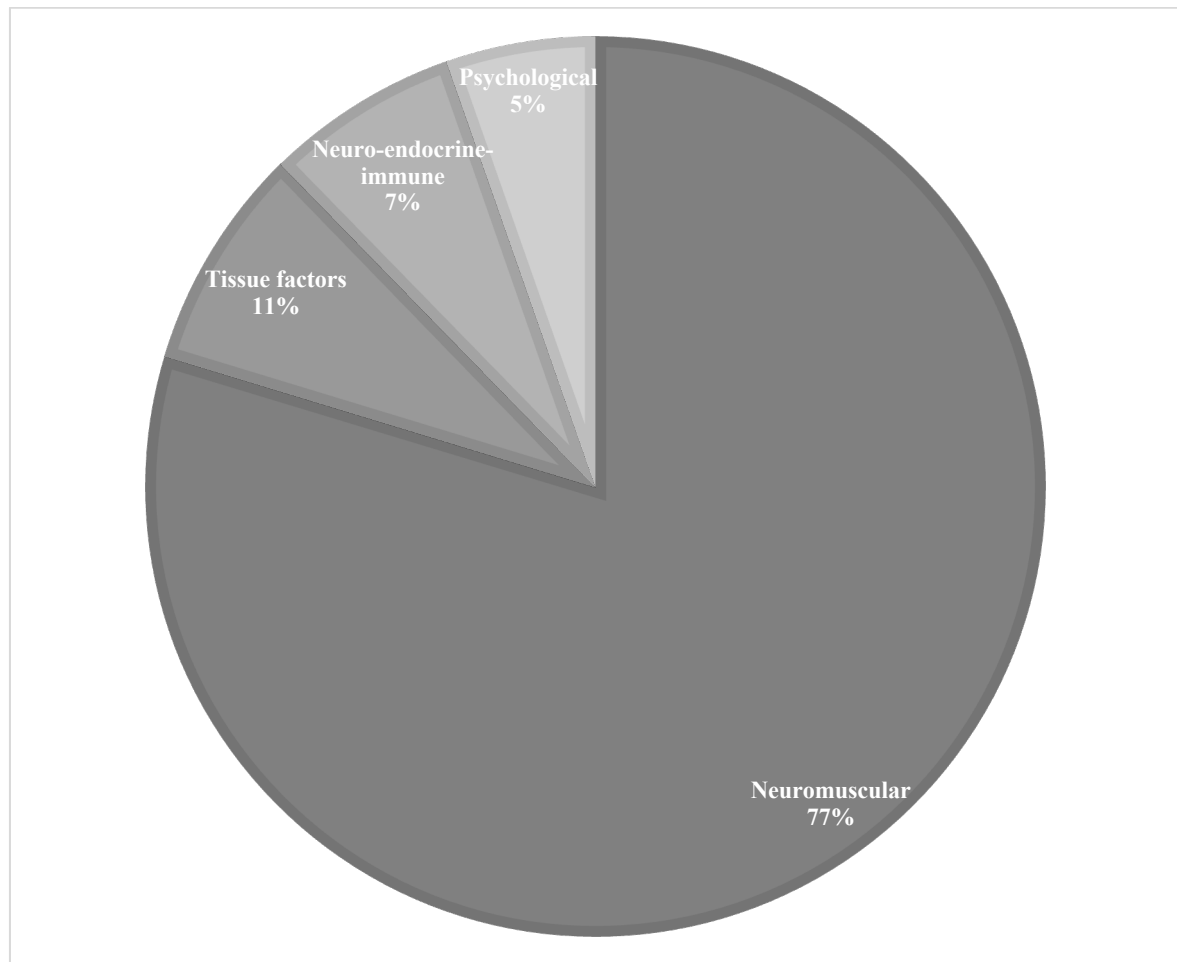


Table 6: Summary of exercise interventions in included studies

Exercise types (n=9)	Exercise packages (n=27)		
Resistance exercise (n=102)	Resistance exercise + stretching exercise + mobility exercise (n=27)	Motor control exercise (unimodal) (n=4)	Resistance exercise + mobility exercise + stretching exercise + motor control exercise + aerobic exercise + postural exercise (n=1)
Stretching exercise (n=68)	Resistance exercise + stretching exercise (n=16)	Resistance exercise + mobility exercise + motor control exercise + stretching exercise + postural exercise (n=3)	Resistance exercise + motor control exercise + stretching exercise + postural exercise (n=1)
Mobility exercise (n=61)	Resistance exercise + mobility exercise (n=14)	Resistance exercise + motor control exercise + postural exercise (n=3)	Resistance exercise + mobility exercise + aerobic exercise (n=1)
Motor control exercise (n=44)	Resistance exercise (unimodal) (n=13)	Resistance exercise + stretching exercise + mobility exercise + proprioceptive exercise (n=2)	Resistance exercise + motor control exercise + mobility exercise + postural exercise (n=1)

Postural exercise (n=12)	Resistance exercise + motor control (n=9)	Resistance exercise + mobility exercise + stretching exercise + motor control exercise + plyometric exercise (n=2)	Resistance exercise + aerobic exercise (n=1)
Plyometric exercise (n=5)	Resistance exercise + mobility exercise + motor control + stretching exercise (n=9)	Motor control exercise + stretching exercise + proprioceptive exercise (n=1)	Resistance exercise + motor control exercise + stretching exercise + plyometric exercise (n=1)
Proprioceptive exercise (n=2)	Resistance exercise + motor control + stretching exercise (n=7)	Resistance exercise + stretching exercise + neurodynamic exercise (n=1)	Resistance exercise + stretching exercise + mobility exercise + postural exercise (n=1)
Aerobic exercise (n=2)	Resistance exercise + motor control + mobility exercise (n=3)	Resistance exercise + motor control exercise + plyometric exercise + postural exercise (n=1)	Motor control exercise + proprioceptive exercise (n=1)
Neurodynamic exercise (n=1)	Mobility exercise (unimodal) (n=3)	Stretching exercise (unimodal) (n=1)	Resistance exercise + stretching exercise + postural exercise (n=1)

4.6 DISCUSSION

This review identified 110 randomised trials that used exercise to help manage RCRSP of any duration. Overall, 32 unique mechanisms of exercise were proposed to explain the effect of exercise and these raw mechanisms were subsequently grouped into four themes: 1) neuromuscular, 2) tissue factors, 3) neuro-endocrine-immune, and 4) psychological (see table 5 and figure 6). The 32 different mechanisms identified in this review highlight a degree of uncertainty and disagreement amongst clinical trialists for how and why exercise might be effective for RCRSP. Despite the overall uncertainty, five mechanisms (muscle strength, motor control, acromiohumeral distance, mobility, and soft tissue length/tension) accounted for 71% of all suggested mechanisms. Neuromuscular mechanisms were proposed most often at an order of magnitude higher than the next most common theme, tissue factors. This finding highlights the hitherto principal approach to managing RCRSP with exercise, which is consistent with the kinesio-pathological model, and emphasises that clinical improvements in shoulder pain and function are chiefly explained by the ‘normalisation’ of kinetic, kinematic or motor control ‘impairments’ (210).

A biomedical mechanism appears to be the dominant rationale underpinning the benefits of exercise for RCRSP, as 95% of suggested mechanisms could be classified as biomedical in nature. In this sense, a biomedical mechanism is a variable that can, in principle, be seen (sometimes clinically and sometimes with laboratory equipment) and measured by an external observer. A biomedical mechanism fits neatly into the ‘body-as-machine’ paradigm that still appears to permeate musculoskeletal health care (211, 212). Only 5% of suggested explanations considered

psychological constructs, and social factors were not mentioned. Our findings are both similar and different from reviews with comparable aims. Wun et al 2020 (181) explored the proposed mechanisms of benefit of exercise for people with persistent low back pain. Wun et al constructed five themes that might explain the effect of exercise: neuromuscular, psychosocial, neurophysiological, cardiometabolic, and tissue healing. Excluding cardiometabolic mechanisms, our review identified similar themes. The absence of cardiometabolic mechanisms of exercise in this review is surprising given cardiometabolic/lifestyle factors are accepted risk factors for developing RCRSP specifically and tendon pathology more broadly (213-215). Beckwee et al 2013 (184) explored the mechanisms of exercise for knee osteoarthritis (OA), identifying five themes from their literature search: neuromuscular components, peri-articular components, intra-articular components, general fitness and health, and psychosocial components. The findings of these reviews for persistent low back pain and knee OA, in addition to the results of this review for RCRSP, suggest biomedical mechanisms are the prevailing causal explanation for any benefit derived from therapeutic exercise. The review of Wun et al found that while biomedical mechanisms of exercise were more common for persistent low back pain compared to psychosocial mechanisms, the absolute difference was about 20%. This is in contrast with the findings of this review which show a more comprehensive difference of 90% in favour of biomedical mechanisms. The difference could be attributed to Wun et al 2020 (181) investigating persistent low back where we included studies of acute and persistent RCRSP. Another reason for the difference could be the longer amount of time low back pain has been recognised as a biopsychosocial condition relative to shoulder pain (216). Wun et al 2020 (181) reported 33 unique mechanisms, whilst Beckwee et al 2013 (184) identified 16 mechanisms (concepts) of exercise for persistent low back pain and knee osteoarthritis. Thus, the possible mechanisms of exercise is uncertain across bodily regions and musculoskeletal pathologies.

Neuromuscular mechanisms, such improving shoulder motor control, shoulder muscle strength and acromiohumeral distance were the common causal explanations for the beneficial effect of exercise for RCRSP. These findings conflict with evidence demonstrating shoulder strength (179, 217), scapular kinematics (165), muscle length (218), muscle timing and activity (219) and acromiohumeral distance (32) either change modestly or not at all in response to exercise and that these ‘neuromuscular’ changes are not required for a clinical improvement in shoulder pain and function in people with RCRSP (170). Moreover, other plausible biomedical mechanisms, such as those within the neuro-endocrine-immune theme, were proposed relatively infrequently despite evidence of pathological changes in the biochemical milieu of shoulder soft tissue structures in

people with RCRSP (220). Furthermore, it is credible that exercise could positively influence the biochemical environment of the shoulder (221).

The lack of consideration of psychosocial constructs is in contrast to a growing awareness in the management of people seeking care for musculoskeletal conditions to be less biomedically focussed and more considerate of all the factors that influence human health and pain (154, 222). Given the underwhelming evidence supporting the claim exercise is effective for RCRSP through mechanical intermediaries, we recommend viewing exercise as a multidimensional intervention, capable of improving shoulder pain and human health and wellbeing via biopsychosocial pathways (223-226).

The most common diagnostic label ascribed to the clinical presentation of RCRSP in this review was subacromial/shoulder impingement syndrome. This label was used in 58% of included studies and was four times more common than the next most used diagnostic label (rotator cuff tear tendinopathy/tendonitis). Perhaps, unsurprisingly, most (84%) studies that proposed an increase in acromiohumeral distance as a possible mechanism of exercise used the diagnostic label subacromial/shoulder impingement syndrome. This may lend support to the notion that the way a health condition (RCRSP) is referred to and understood may lead to inaccurate beliefs about how the condition is caused and how to effectively treat it, from both the patient and clinician perspectives (36, 227).

About one third of studies included in this review did not include a specific causal explanation or clinical rationale for their exercise intervention. This is comparable to Wun et al 2020 (181) and did not change over time. This is despite the CONSORT checklist clearly recommending authors consider and state the possible mechanisms and explanation for how their interventions might work (169). Based on the findings of this review, we support the CONSORT checklist and urge clinical trialists to offer a causal explanation or clinical rationale for their exercise interventions, after all explanation is imperative to the aim of science (109).

This review has provided a list of potential mechanisms that independently or in combination may be the reason exercise demonstrates possible benefit in the management of RCRSP. We do not speculate that these mechanisms are or are not causally related to RCRSP. It is a list, constructed through screening the introduction and discussion of included randomised clinical trials. Furthermore, the identified mechanisms are not to be confused with mediating factors. A mediating factor is an intermediary variable (for example shoulder strength) that is affected by the intervention (for example, resistance exercise), which then causally affects the outcome (for

example shoulder pain). The list of mechanisms highlighted in this review are explanatory hypotheses and possible treatment targets that could be tested as mediators using mediation analysis methodology (228).

The findings of this review must be considered with acknowledged limitations. Importantly, some aspects of this review were qualitative and might be open to interpretation, particularly identifying specific causal mechanisms and then organising them into cogent themes. Although PEDro indexes 99% of clinical trials (183), there is a possibility we may have missed studies that would have met our inclusion criteria. We used a popular definition of ‘mechanism’ for the purposes of this review, however it must be acknowledged that precisely what constitutes a mechanism and how best to define it remains a topic of debate in the field of philosophy of science (229). Moreover, we decided to include studies that did not have an exercise-only arm of the trial to include more studies into the review (only 51% of included trials had an exercise-only arm). As such, exercise was often provided with other common physiotherapeutic interventions, which may have led to clinical trialists focusing on reporting possible causal mechanisms of other interventions and not exercise (199). We did not include single arm cohort studies in our review, which might have led to the identification of more mechanisms of exercise. Finally, the findings of this review might, to some extent, be unsurprising because exercise is often perceived to be a physical intervention that primarily targets mechanical intermediaries (e.g. strength and flexibility) (230). However, the profound disproportionate priority assigned to possible biomedical mechanisms of exercise for RCRSP in clinical research is revealing and challenges any notion of the metaphorical pendulum swinging too far in the direction of the psychosocial.

This review set out to synthesise the mechanisms hypothesised to explain the benefits of exercise for RCRSP. Our findings identified varied mechanisms that were able to be grouped into four themes. Neuromuscular mechanisms were the most common theme, with motor control and muscle strength the most proposed individual mechanisms. Biomedical mechanisms accounted for a significantly disproportionate percentage of proposed mechanisms relative to psychosocial, which might warrant further research and reflection. The list of mechanisms identified in this review should be scrutinised in future research, perhaps using mediation analysis, which may improve understanding of how exercise might be beneficial for RCRSP leading to more effective and biologically plausible exercise prescription.

CHAPTER 5: Physiotherapists nearly always prescribe exercise for rotator cuff-related shoulder pain; but why? A cross-sectional international survey of physiotherapists

5.1 PREFACE

The scoping review of Chapter 4 mapped the common causal explanations proffered by clinical trialists for the beneficial effect of exercise for RCRSP. Biomedical mechanisms including muscle strength and motor control, accounted for the majority of proposed causal explanations.

In chapter 5, we aimed to compare and contrast the causal explanations proffered in clinical research to those of practising physiotherapists. To the best of our knowledge, no research had specifically explored the beliefs of physiotherapists about how and why they believe exercise to be effective for RCRSP. Understanding the beliefs of physiotherapists is important because they provide explanatory information to individuals with RCRSP about why they are being prescribed an exercise program and how it is expected to help them.

The following manuscript was published in *Musculoskeletal Care* (see appendix 5.1).

Powell JK, Schram B, Lewis J, Hing W. Physiotherapists nearly always prescribe exercise for rotator cuff-related shoulder pain; but why? A cross-sectional international survey of physiotherapists. *Musculoskeletal Care*. 2022.

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Open access version at: <https://doi.org/10.1002/msc.1699>

5.2 ABSTRACT

Background

This cross-sectional international survey explored the beliefs of physiotherapists regarding the possible mechanisms of benefit of exercise for rotator cuff-related shoulder pain (RCRSP). Clinical practice guidelines recommend physiotherapists use exercise as a primary treatment to help people with RCRSP, but the explanations provided to patients by physiotherapists regarding its mechanism of effect is unknown.

Materials and Methods

Registered physiotherapists were surveyed about ‘how and why’ they believe exercise provides a clinical benefit for people with RCRSP. Information was also gathered about commonly used exercise types and preferred diagnostic labels. The survey was designed and reported in concordance with Consensus-Based Checklist for Reporting of Survey Studies (CROSS) guidelines.

Results

Four hundred and eighty physiotherapists from forty-nine countries completed the survey. Psychosocial and biomedical mechanisms of exercise were evenly selected by participants. Improving muscle strength, muscle endurance, pain self-efficacy and reducing kinesiophobia, and fear avoidance beliefs were the most common individual mechanisms thought to underpin exercise therapy for RCRSP. RCRSP was the most commonly used diagnostic label.

Discussion and Conclusion

Physiotherapists hold beliefs regarding exercise mechanisms that is largely concordant with the current evidence base, which is commendable. Future research should consider the patients perspective and consider testing commonly selected mechanisms of exercise, such as shoulder muscle strength, pain self-efficacy and kinesiophobia as possible mediators of recovery.

5.2.1 Keywords

Exercise, shoulder pain, exercise mechanisms, physiotherapy, rotator cuff, strengthening

5.3 INTRODUCTION

Shoulder pain is common and impacts on myriad functions of life (4, 231). Rotator cuff-related shoulder pain (RCRSP) is reported to be the most frequent manifestation of shoulder pain (8) and unfortunately can prove resistant to medical, surgical and non-surgical interventions. The veracity and usefulness of RCRSP as a diagnostic label for shoulder pain has been explored elsewhere (37, 42, 44, 46, 232).

Many treatments, with similar effectiveness, exist to help people suffering with RCRSP. Of the treatments available, education and exercise therapy are widely recommended as a practical, sensible, and high value first-line intervention (74, 103). Therefore, exercise is the primary focus of this publication. Whilst uncertainty exists regarding the absolute benefit of exercise therapy for managing RCRSP (178), similar could be said for most (if not all) available treatment options, whether surgical or non-surgical. A possible explanation for the hitherto observed modest clinical effects of exercise for people with RCRSP is the enduring ambiguity of ‘how and why’ shoulder exercise may influence the experience of shoulder pain. Put simply, if a person experiences an improvement in shoulder pain or function in response to an exercise program, how this occurred is currently unclear. Conversely, if a person doesn’t experience a clinical benefit in response to exercise, we often don’t know why. This lack of knowledge about treatment mechanisms is not limited to exercise or to the shoulder (123) and is an area of burgeoning research interest (233). Biopsychosocial mechanisms underpinning exercise for musculoskeletal conditions have been proposed (224), however there is a dearth of research specifically testing these mechanisms for RCRSP.

Research has been conducted investigating the mechanisms proposed by clinical trialists for the beneficial effect of exercise for RCRSP, persistent low back pain and knee osteoarthritis (181, 184, 234). Despite this, to the best of the authors knowledge, no research to date has explored the beliefs of practising physiotherapists regarding the possible causal mechanisms of exercise therapy for managing RCRSP. This is despite the overwhelming majority (up to 99.8%) of physiotherapists reporting they would prescribe exercise for people presenting with signs and symptoms resembling RCRSP (94). Understanding clinician perspectives is important because it is the clinician who is tasked with providing explanatory information about the available treatments during shared decision making. In turn, it is often these explanations that patients latch onto (235), which have the potential to influence perceptions of their condition.

Given the role physiotherapists undertake in helping people with RCRSP, most often via the prescription of exercise, the primary aim of this study was to explore how physiotherapists believe exercise may provide benefit for individuals with RCRSP. Secondary aims were to compare the beliefs of practising physiotherapists with mechanisms proposed by clinical trialists, and to determine whether there is a difference between physiotherapists with and without a special interest in musculoskeletal shoulder pain pertaining to whether they believe biomedical or psychosocial mechanisms most often underpin exercise therapy.

5.4 METHODS

5.4.1 *Design*

This study is a cross-sectional online international survey exploring physiotherapists' beliefs of the possible mechanisms underpinning exercise therapy in the management of RCRSP. The design of this study was partly inspired by a previous published survey exploring physiotherapy practice for RCRSP (95). The design was chosen to capture, globally and at scale, the average viewpoint of physiotherapists regarding mechanisms of exercise for RCRSP. The design and reporting of this survey is concordant with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) guidelines (236).

5.4.2 *Ethics*

Ethical approval for this survey was obtained by the Bond University Human Research Ethics Committee (JP03070).

5.4.3 *Survey development*

The authors developed an original 22-item survey (Appendix 3) using Qualtrics software (Qualtrics, Provo, Utah) guided by the results of a recent scoping review of commonly suggested mechanisms of exercise for RCRSP as proposed in clinical research (234). The survey was divided into three main sections. Section one was designed to capture participant demographic information. Section two was designed to identify the beliefs of physiotherapists about the possible mechanisms underpinning exercise therapy for RCRSP. Section three was designed to elicit information about the practice of measuring shoulder strength, what diagnostic labels physiotherapists use to describe a clinical presentation resembling RCRSP and whether knowledge of treatment mechanisms was important to their clinical practice. The survey employs the use of a clinical vignette to help orient participants towards a 'typical' clinical presentation of RCRSP. The clinical vignette was adapted from Bury and Littlewood, 2018 (95) and is documented in Box 1 below. The pretesting process of the survey was 2-staged and involved 15 physiotherapists. Stage 1 involved pretesting the survey

with 5 registered physiotherapists in Australia (male = 4, female = 1), after which minor amendments were made to the wording and structure of survey questions to improve flow. Stage 2 involved pretesting the survey with 10 (male = 6, female = 4) registered physiotherapists from Australia (n=5), United Kingdom (n=2), North America (n=2) and Thailand (n=1) and appropriate minor modifications were made to wording and adding skip logic functions where necessary.

Box 1: Clinical Vignette

A 52-year-old man presents to you with a 6-month history of non-traumatic, gradual onset, right-sided shoulder pain. The man works as a financial planner and thus is not engaged in labour intensive work. The pain is predominately confined to the anterolateral region of the shoulder. There are no radiculopathy symptoms or referral of pain down the arm or up the neck. Pain intensity is mild to moderate in nature, rising to 5/10 at worst and is negligible at rest. Pain type is typically dull unless aggravated, in which the pain can become sharper. Aggravating factors are shoulder abduction (painful arc sign), reaching behind the back and sleeping on the affected side. There is no history of shoulder dislocation or feelings of instability. Passive range of motion (ROM) of the shoulder is preserved. Shoulder external rotation strength, as measured by a hand-held dynamometer, is reduced by 20% on the affected side versus the unaffected side but a massive full thickness rotator cuff tear is not suspected. Cervical spine ROM is full and pain free. The acromioclavicular joint is unremarkable. An ultrasound scan of the affected shoulder has been performed, which reveals tendinopathy of the supraspinatus and thickening of the subacromial bursa. There are no relevant co-morbidities. The pain is impacting the man's quality of life, mainly disrupting sleep and the ability to participate in his weekly tennis match.

5.4.4 Sampling and recruitment

Physiotherapists were able to participate in this study if they were, 1) registered with their national accrediting body, 2) at the time of the survey were treating people seeking care for shoulder pain, 3) aged 18 years and above, and 4) were proficient in the English language. Convenience sampling was used to recruit potential participants via the social media platforms Twitter™, Instagram™ and Facebook™. One month after the initial advertisement of the survey on the social media platforms, a reminder was posted to prospective participants. This recruitment strategy was hypothesised to be sufficient to obtain a sample size of ≥ 350 participants, which was adequate in previous comparable research (94, 95). The survey was live online between March 30 and May 9, 2022.

5.4.5 Statistical analysis

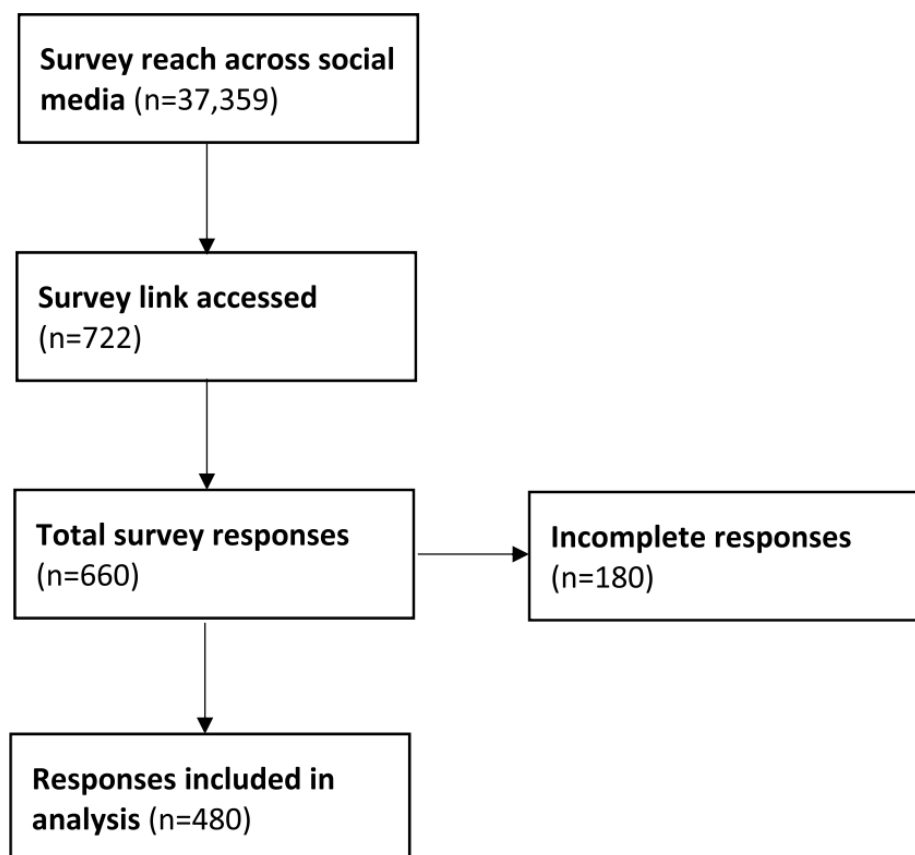
Data was collected via Qualtrics software (Qualtrics, Provo, Utah) and exported to SPSS v28 (IBM Corp, Chicago, Illinois, USA) for statistical analysis. We set a threshold that minimum 60% of the survey be completed to be included in the final analysis. Descriptive statistics were used to summarise the data and Chi-square tests (alpha 0.05) were used to compare those with and without a special interest in shoulder pain for whether they thought biomedical or psychosocial

factors most often underpinned the effect of exercise for RCRSP. Qualitative responses were categorised into cogent themes using thematic analysis (237) and, where appropriate, incorporated into the main dataset.

5.5 RESULTS

A total of 660 physiotherapists returned responses to the survey. One hundred and eighty responses were excluded for completing less than 60% of the survey, leaving 480 responses for inclusion in the final analysis (73% of the original sample). Figure 7 illustrates the flow of participants through this study. The survey took approximately 10 minutes to complete.

Figure 7: Flow of participants through study

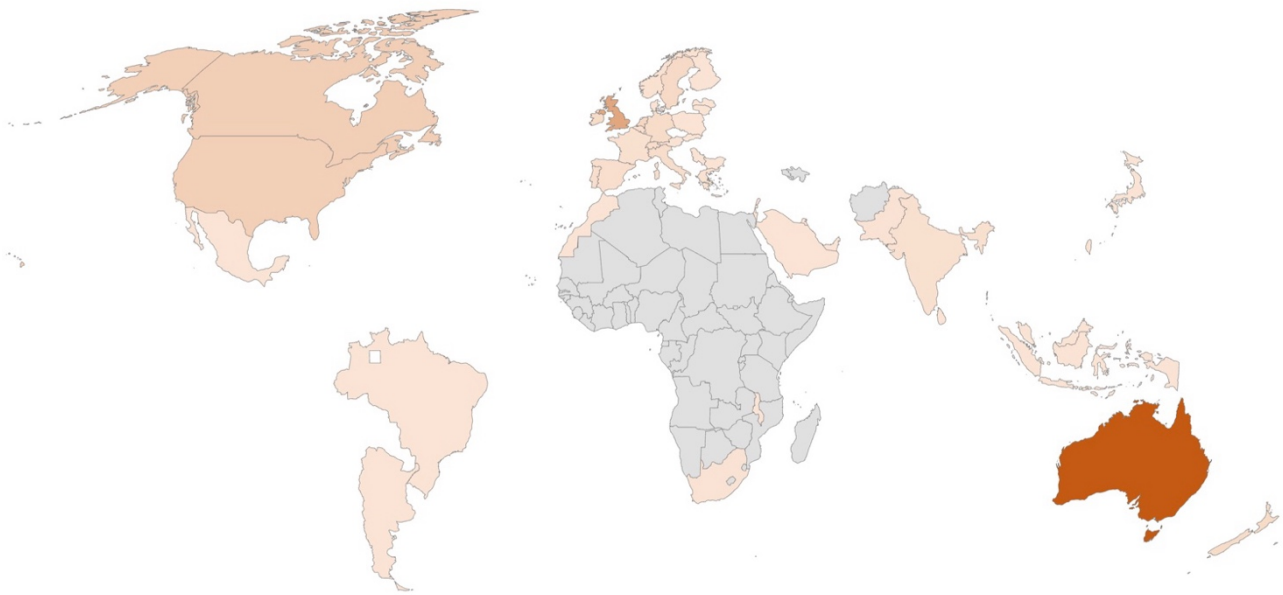


The demographic information of the participants in this study is displayed in Table 7. Most respondents were male (61.3%), from Australia/New Zealand (38%), worked in private practice (72.1%) and indicated they had a self-reported special interest in shoulder pain (65.2%). The participants were from 49 different countries and all but one continent (Antarctica) was represented (Figure 8).

Table 7: Participant demographic information

	Mean (range)	Standard deviation
Age†	34.2 (20-66)	9.8
Gender	Frequency (n)	Total (%)
Male	294	61.3%
Female	185	38.5%
Non-binary/third gender	1	0.2%
Total	480	100%
Clinical experience		
<5 years	204	42.5%
5-10 years	83	17.3%
10-15 years	65	13.5%
15-20 years	44	9.2%
>20 years	84	17.5%
Total	480	100%
Location of registration		
Australia and New Zealand	182	38%
Continental Europe	119	25%
Great Britain and Ireland	88	18%
Northern America	56	12%
South America	2	0%
Middle East and Northern Africa	11	2%
Southern Africa	4	1%
Asia	18	4%
Total	480	100%
Average number of shoulder pain cases treated per week		
Less than 5	108	22.5%
5-10	248	51.6%
11-15	71	14.8%
>15	53	11%
Total	480	100%
Clinical setting‡		
Private practice	344	72.1%
Hospital inpatients	6	1.3%
Hospital outpatients	90	18.9%
Aged care facility	2	0.4%
Community health	25	5.2%
Professional sport	10	2.1%
Total	477	100%
Special interest in MSK shoulder conditions		
No	167	34.8%
Yes	313	65.2%
Total	480	100%

Figure 8: Countries represented in the survey



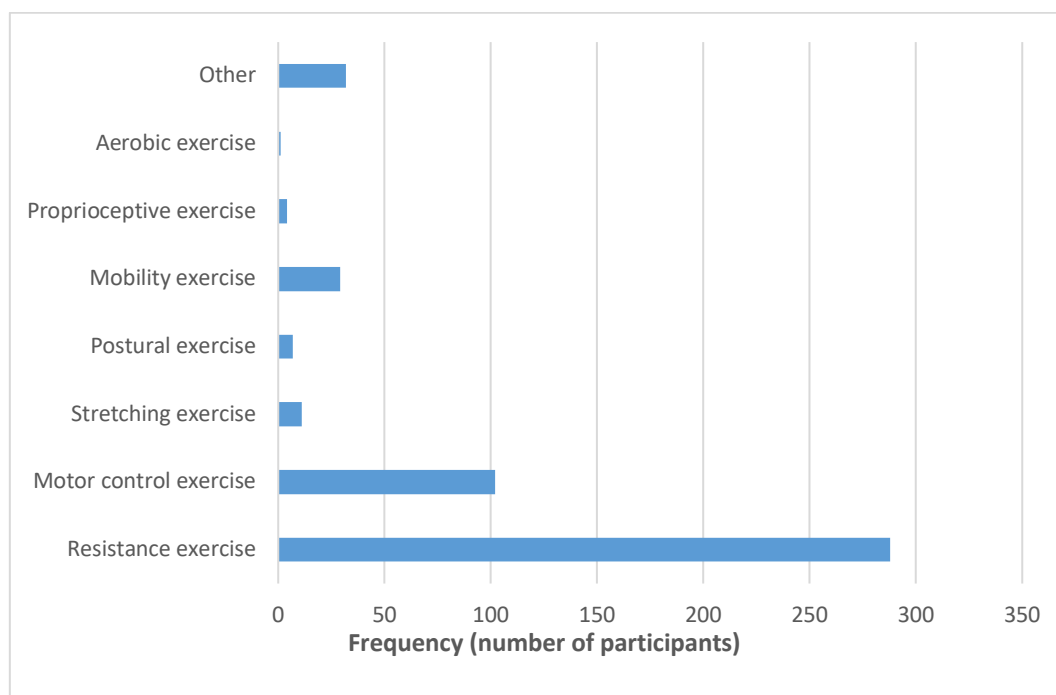
5.5.1 Would you prescribe exercise for this clinical presentation?

Almost all (99%) respondents indicated they would prescribe exercise for the type of presentation described in the clinical vignette.

5.5.2 Exercise type

Resistance exercise was the most common type of exercise physiotherapists would prescribe for the clinical presentation described in the vignette (288/474; 60.8%). Resistance exercise was selected approximately three times more often than the next most common type of exercise, motor control exercise (102/474; 21.5%) (Figure 9). The most common ‘other’ exercise type was a combination of exercise types (19/474; 4%).

Figure 9: Exercise types selected to manage the presentation described in the clinical vignette



5.5.3 Exercise mechanisms

Respondents selected a balanced variety of mechanisms to explain the clinical effectiveness of exercise for RCRSP. Psychosocial factors were selected most often (325/472; 68.9%) followed by neuromuscular factors (289/472; 61.2%), neurophysiological factors (58.3%) and tissue healing factors (45.3%) (Figure 10). ‘Other’ mechanisms were proposed rarely (8/472; 1.7%) with the most common being a combination of all suggested mechanisms (6/8; 75%).

Among neuromuscular mechanisms, increased muscle strength (n=293), muscle endurance (n=239) and enhanced shoulder motor control (n=238) were the most selected mechanisms to explain possible improvements in shoulder pain and function with shoulder exercise. An increase in acromiohumeral distance was the least selected mechanism (n=19) (Figure 11).

Psychological mechanisms were deemed important by the vast majority of respondents (431/475; 90.7%). The specific psychological mechanisms selected were relatively evenly spread; with kinesiophobia (n=354), pain self-efficacy (n=308), and fear avoidance beliefs (n=306) the most selected psychological mechanisms to explain the possible effectiveness of shoulder exercise. Depression (n=83) and anxiety (n=129) were selected the least (Figure 12).

When dichotomised into either biomedical or psychosocial mechanisms to explain the effect of shoulder exercise, psychosocial mechanisms (249/473; 52.6%) were selected slightly more often

than biomedical mechanisms (224/473; 47.4%). Respondents with a self-reported special interest in musculoskeletal shoulder pain were significantly more likely to select psychosocial mechanisms (173/307; 56.4%) than those without a self-reported special interest (76/166; 45.8%) (Chi-Squared = 4.8, $p = 0.028$).

Physiotherapists were uncertain regarding the importance of tissue healing mechanisms in response to exercise for shoulder pain, with approximately half believing it is important (234/457; 51%) and half believing it is not important (223/457; 49%). In contrast, most physiotherapists in this cohort (394/455; 87%) believe neurophysiological factors to be an important mechanism underpinning exercise.

Figure 10: Mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette

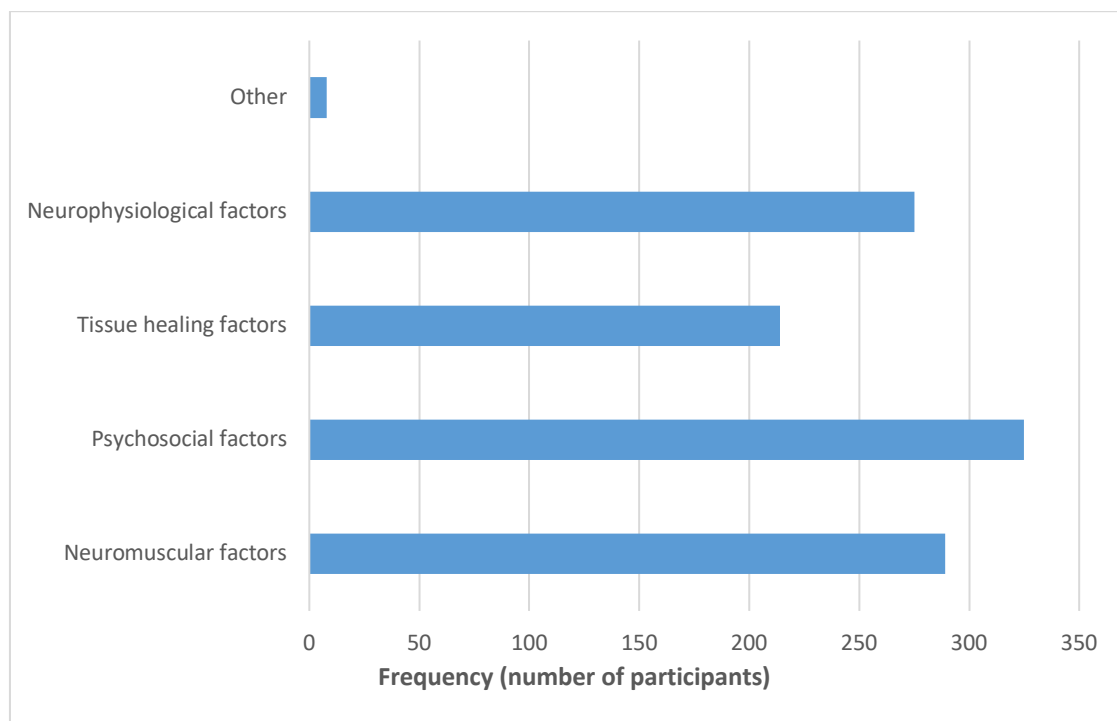


Figure 11: Neuromuscular mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette

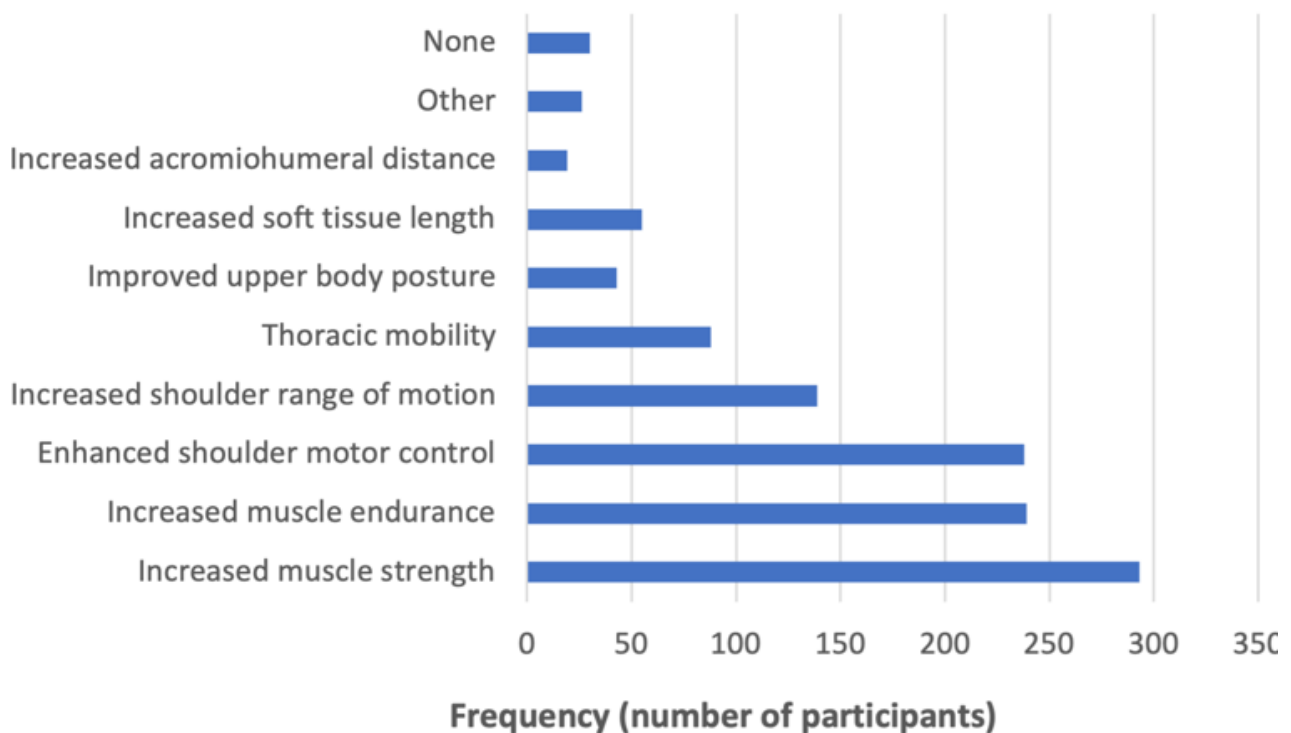
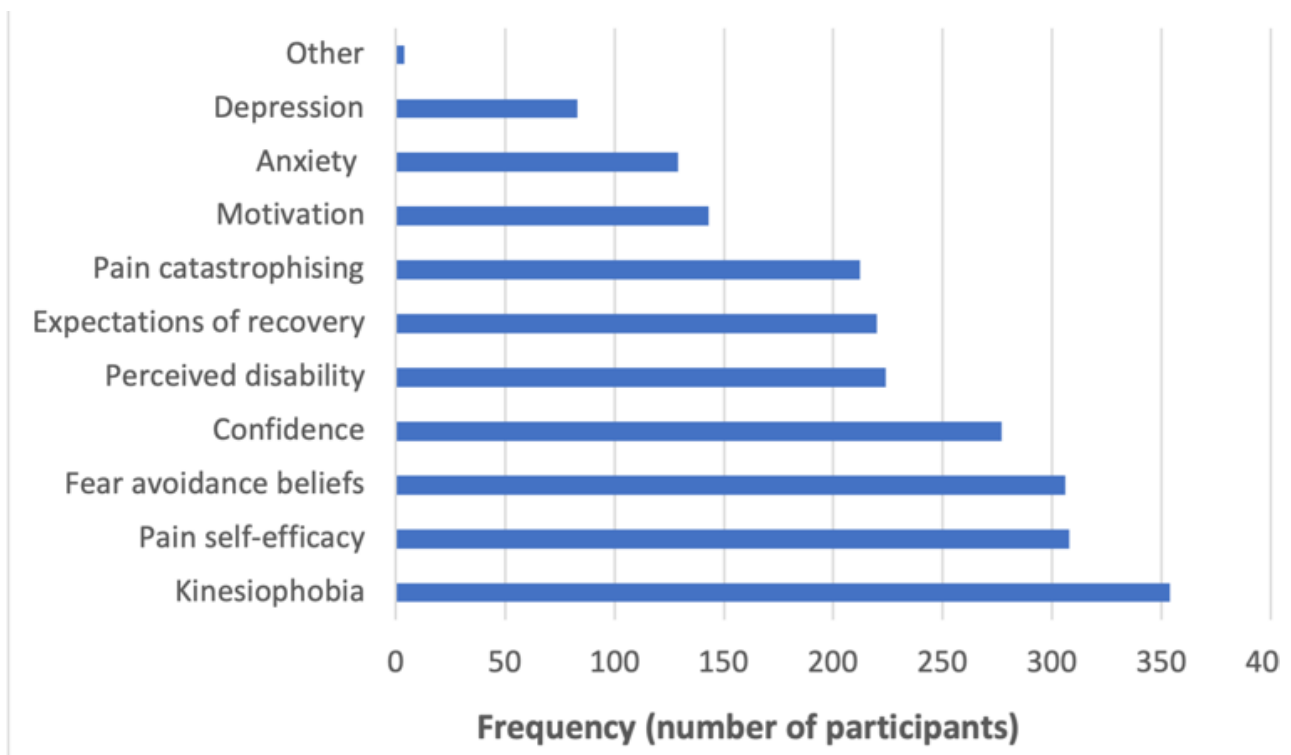


Figure 12: Psychological mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette



5.5.4 *Scapular dyskinesis*

Most physiotherapists in this cohort (303/461; 66%) did not believe that an identified scapular dyskinesis need be rectified or optimised for shoulder pain and function to improve.

5.5.5 *Shoulder weakness*

Most physiotherapists in this cohort (275/459; 60%) believed the external rotation weakness described in the clinical vignette should be a primary target for treatment.

5.5.6 *Posture*

Slightly more physiotherapists in this cohort (266/462; 58%) did not believe that any detected postural abnormalities of the shoulder complex (including the thoracic spine) to be an important treatment target.

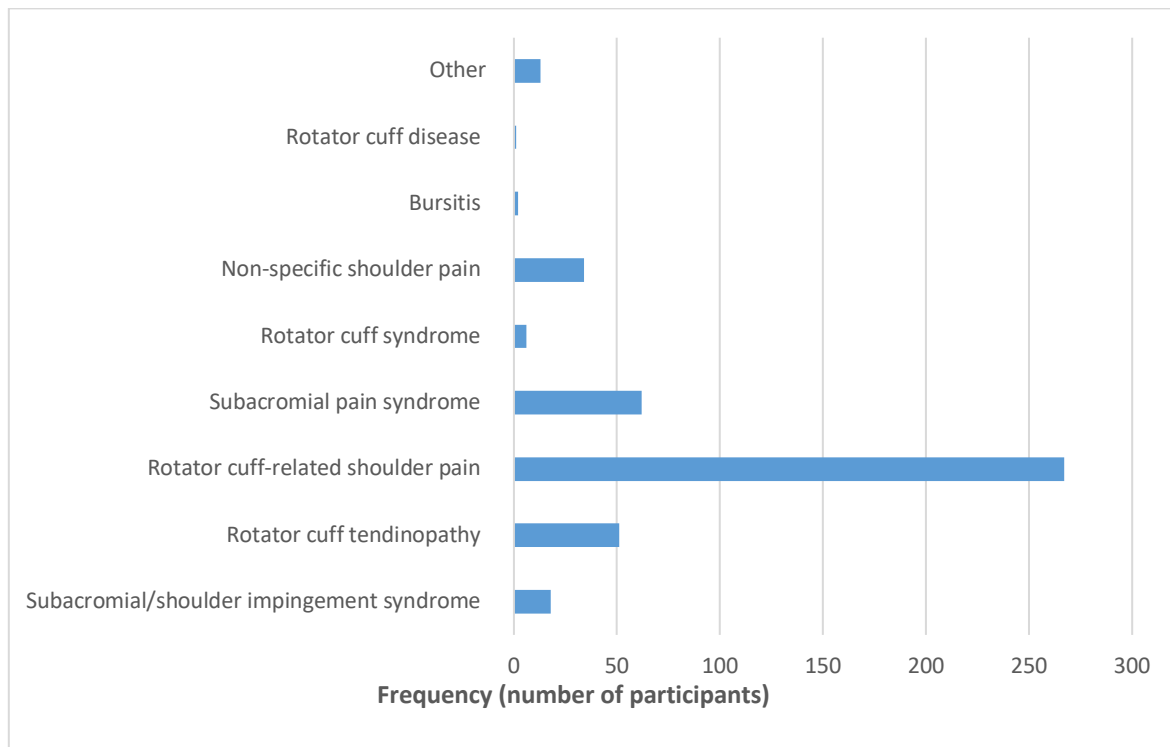
5.5.7 *Shoulder strength measurement*

Most physiotherapists in this cohort (355/463; 77%) indicated they regularly measure shoulder strength in their clinical practice. The most common method of measuring maximal shoulder strength was manual muscle testing (193/348; 56%) followed by handheld dynamometry (113/348; 33%) and isokinetic testing (20/348; 6%). ‘Other’ methods suggested by respondents included using a force frame (n=8) and using various repetition maximum tests (n=7).

5.5.8 *Diagnostic label*

Most physiotherapists in this cohort (267/454; 59%) selected RCRSP as the diagnostic label they would use for the clinical presentation described in the vignette (Figure 13). RCRSP was selected four times more often than the next most common diagnostic label, subacromial pain syndrome (62/454; 14%) and rotator cuff tendinopathy (51/454; 11%). The traditionally common diagnostic labels subacromial/shoulder impingement syndrome (18/454; 4%), shoulder bursitis (2/454; 0.4%) and rotator cuff disease (1/454; 0.2%) were selected relatively infrequently. Some respondents suggested ‘other’ diagnostic labels including sensitive shoulder (n=2), shoulder irritation (n=2), and weak and painful shoulder (n=1).

Figure 13: Diagnostic label preferred by physiotherapists to describe the presentation in the clinical vignette



5.5.9 Knowledge of exercise mechanisms

The vast majority of participants in this survey (408/455; 90%) indicated that more knowledge on the possible mechanisms of exercise for shoulder pain would benefit their clinical practice.

5.6 DISCUSSION

The results of this international cross-sectional survey suggest physiotherapists hold beliefs regarding exercise mechanisms for RCSRSP that is largely concordant with the current evidence base. In fact, it appears practicing physiotherapists, in this cohort, hold beliefs regarding the possible mechanisms of exercise that more closely approximates contemporary scientific research compared to the explanations proffered in randomised clinical trials (234).

Almost all (99%) physiotherapists who participated in this survey indicated they would prescribe some form of exercise for a clinical presentation resembling RCSRSP. This is similar to previous published surveys of physiotherapists from around the world (94-96) and is consistent with recommendations from both clinical practice guidelines (93) and systematic reviews (74, 97, 101). Uncertainty remains regarding the absolute effectiveness of exercise for RCSRSP (178) and this

study does not address or mitigate this uncertainty, however, physiotherapists in this cohort do adhere to recommendations in the scientific literature. Resistance exercise was clearly the most common type of exercise physiotherapists would prescribe for people with RCRSP and was three times more common than motor control exercise. It is unclear why resistance exercise was clearly the most popular exercise type to manage RCRSP. Resistance exercise to ‘strengthen’ muscles of the shoulder complex is a recommended intervention (97) and is possibly effective for people with RCRSP (156) but it is unclear if resistance exercise is clinically superior to motor control exercise (238). Perhaps simple progressive resistance exercise is considered a more parsimonious exercise approach to manage RCRSP and there is evidence that perceived complexity can be a barrier to initiating and maintaining participation in exercise (239).

Physiotherapists surveyed in this study, somewhat surprisingly, selected psychosocial mechanisms of exercise more often than biomedical mechanisms. In fact, 91% of physiotherapists believe psychosocial constructs to be important mechanisms underpinning the possible effectiveness of exercise for RCRSP. This is in complete contrast to a recent scoping review investigating proposed mechanisms of benefit of exercise for RCRSP in randomised clinical trials (234). This scoping review reported only 5% of all proposed mechanisms of exercise in clinical research were related to psychosocial constructs (234). This appears to indicate that practising physiotherapists might hold a more rounded understanding of the probable multifactorial causal effect of exercise for RCRSP compared to clinical researchers and reiterates appeals for clinicians and researchers to work together in the research process (240). Kinesiophobia, pain self-efficacy and fear avoidance beliefs were the specific psychological mechanisms selected most often. These psychological constructs appear to be associated with clinical outcomes in people with shoulder pain (241-243) but it is unclear to what extent exercise can modify these constructs or if they are valid mediators of recovery for people with RCRSP. There is evidential support in osteoarthritis research for self-efficacy as a mediator of recovery (244) and it is plausible this could be the case for RCRSP too (245).

Among neuromuscular mechanisms, muscle strength and muscle endurance were most proffered by physiotherapists. This is most likely correlated to resistance exercise being found to be the most popular exercise type to manage RCRSP in this survey. Muscle strength is also a popular causal explanation proposed in clinical research (234), indicating agreement between clinicians and clinical researchers. Just how relevant improvements in shoulder strength are in the clinical outcomes of people with RCRSP is currently uncertain (170, 246) but evidence from knee osteoarthritis research suggests it is a plausible mediator of positive clinical outcomes (247).

Interestingly, an increase in acromiohumeral distance was the least proposed neuromuscular mechanism in this study, which accurately reflects the evidence base (32). This diverges from the explanations proffered by clinical researchers (234), in which acromiohumeral distance was one of the more common neuromuscular mechanisms proposed. This may suggest, in this cohort at least, clinicians are evolving with the evidence, and this is to be commended.

The importance of tissue healing as a reason to prescribe exercise remains equivocal for the participants in this survey. This probably reflects the lack of consensus in the literature and is an area where research is required. Currently, it appears macroscopic tendon structure need not improve for pain and function to improve (166, 248), however it is plausible that changes in the microscopic biochemical environment of the rotator cuff and subacromial bursa may influence clinical outcomes (249). As such, it is unsurprising that 90% of respondents to this survey believe more knowledge on the possible mechanisms of exercise for shoulder pain would support their clinical practice.

Most physiotherapists in this study do not believe scapular dyskinesis or upper body postural abnormalities represent important treatment targets. This belief is backed up by high quality evidence, which suggests that while scapular focused exercise is effective at reducing shoulder pain and improving function, it does not seem to do so via a change in scapular motion (246, 250). A recent secondary mediation analysis of a randomised controlled trial (246) reported scapular motion and position did not mediate the effect of scapular focused exercise on shoulder pain and disability in a cohort of people with RCRSP. Moreover, the relationship between static posture and shoulder pain and function are currently tenuous (251). Again, physiotherapists should be commended for holding beliefs that align with contemporary evidence.

Most physiotherapists indicated measuring shoulder force output (strength) was an important part of their clinical practice, and the most common measurement method was manual muscle testing (MMT). MMT can be a reliable method of measuring shoulder force output (252) but is less sensitive and more subjective compared to hand held dynamometry (HHD) and isokinetic testing (253). It is arguably a sensible and pragmatic recommendation for physiotherapists to consider using a HHD, especially given the increasing affordability of these devices (254). What clinicians then do with the information derived from the measure is another question entirely, is subject to variation based on the individual clinical context and is the focus of ongoing academic discussion.

The diagnostic label favoured by physiotherapists in this survey was, compellingly, RCRSP. This finding agrees with a recent consensus study of shoulder experts (43) and reflects the cultural and academic momentum to move away from inaccurate and potentially harmful pathoanatomical diagnostic labels such as subacromial/shoulder impingement syndrome and rotator cuff tear (37, 42, 232, 255). Intriguingly, clinicians appear to be more cognisant of current trends in best practice management of shoulder pain compared to researchers, who still overwhelmingly use the term subacromial/shoulder impingement syndrome (234).

The findings of this survey must be considered in light of its limitations. We used a convenience sampling recruitment method and were unable to calculate an exact response rate. The survey reached >37,000 potential participants across the social media platforms Instagram™, Twitter™, and Facebook™, however, it is impossible to know what proportion were registered physiotherapists. It is important to acknowledge a possible selection bias too with most participants being male, with a self-reported special interest in shoulder pain, working in private practice and from an English speaking and highly economically developed country. Therefore, the findings of this survey must be interpreted within this context. Moreover, using the authors social media platforms may bias the sample due to familiarity of work. Inherent to de-identified surveys is the problem of screening participants and there is a chance that not all who completed the survey were registered physiotherapists. Whilst the use of clinical vignettes in health research to elicit knowledge, opinions, or attitudes from study participants has many benefits, there are limitations, particularly with external validity (256). We attempted to mitigate this limitation by basing our vignette on published precedents (94, 95), thoroughly analysing the evidence-base, and pretesting it to physiotherapists in order make it as generalisable and robust as possible.

5.7 CONCLUSION

Physiotherapists in this cohort believe exercise may be effective for RCRSP via a combination of biomedical and psychosocial mechanisms, with a slight leaning towards psychosocial. Improving muscle strength, muscle endurance, pain self-efficacy and reducing kinesiophobia, and fear avoidance beliefs were the most common individual mechanisms thought to underpin exercise therapy for RCRSP. The term RCRSP was the term of choice identified by respondents of this survey. Subsequent research should attempt to determine if these mechanisms are valid mediators of recovery in response to an exercise program in people with RCRSP.

CHAPTER 6: “Restoring that faith in my shoulder”: A qualitative investigation of how and why exercise therapy influenced the clinical outcomes of individuals with rotator cuff-related shoulder pain

6.1 PREFACE

In Chapter 5, we extended our understanding and knowledge of the possible causal mechanisms of exercise for RCRSP by surveying practising physiotherapists. Thus, we have now accumulated evidence from clinical research (Chapter 4) and practicing clinicians (Chapter 5) about how and why exercise is hypothesised to help an individual with RCRSP. There were some discrepancies between clinicians and clinical researchers, most notably in the acknowledgement of psychological mechanisms, which was surprising. There were also some commonly held beliefs between clinicians and researchers, specifically that muscle strength was a key mechanism underpinning clinical improvements through engaging with an exercise program.

In Chapter 6, we aim to extend the knowledge derived from Chapters 4&5, that are more quantitative in method, by conducting qualitative research in the form of semi-structured interviews to capture the individuals lived experience. The lived experience of individuals with RCRSP has largely been overlooked in the evidence-base in terms of how and why exercise was perceived to help or hinder their shoulder pain. Furthermore, the clinical conditions that supported or inhibited a positive clinical outcome had not been specifically and thoroughly explored. The qualitative study of this chapter was guided by a critical realist philosophy, which is appropriate when the primary research question seeks a causal explanation for a particular event or experience. A critical realist philosophy also facilitates investigation into the dynamic interplay between intervention – context – mechanism – outcome, which hitherto, had not been explored.

The following manuscript was published in *Physical Therapy and Rehabilitation Journal* (Appendix 4).

Powell JK, Costa N, Schram B, Hing W, Lewis J. "Restoring that Faith in my Shoulder": A Qualitative Investigation of how and why Exercise Therapy Influenced the Clinical Outcomes of Individuals with Rotator Cuff-Related Shoulder Pain. *Phys Ther*. 2023.

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Open access version at: <https://doi.org/10.1093/ptj/pzad088>

6.2 ABSTRACT

Objective

Rotator cuff related shoulder pain (RCRSP) is the most common form of shoulder pain. Exercise therapy is a first-line recommended treatment for RCRSP, however, the causal mechanisms underpinning the beneficial effects of exercise for RCRSP are not well understood. Moreover, how individuals with lived experience of RCRSP believe exercise helped or didn't help them is unknown. This study aimed to gain insights into how individuals with RCRSP believe exercise influenced their shoulder pain and identify the clinical conditions that promoted or inhibited this.

Methods

This qualitative study was underpinned by a critical realist approach to thematic analysis. Participants were recruited using hybrid purposive and convenience sampling techniques. Each participant attended an online semi-structured interview. The data were coded by two members of the research team (JKP & NC) and verified by a third (BS). Recruitment continued until theoretical sufficiency was achieved. Participants reviewed and validated preliminary causal explanations.

Results

Three causal explanations were consistently expressed by 11 participants to explain the benefits of exercise therapy: 1) shoulder strength, 2) changes to psycho-emotional status, and 3) exercise has widespread health effects. However, the activation of these causal mechanisms depended on the presence of 1) a strong therapeutic relationship, 2) the provision of a structured and tailored exercise program, and 3) experiencing timely clinical progress.

Conclusions

Participants believed exercise improved their shoulder pain by its associated benefits to health, improving shoulder strength, and through psycho-emotional variables. Whether an exercise program was able to cause a clinical improvement for an individual with RCRSP was contingent on clinical contextual features. Thus, the clinical context that an exercise program is delivered within may be just as important as the exercise program itself.

Key words

Exercise, rotator cuff, shoulder, shoulder pain, subacromial impingement syndrome

Impact

Exercise is a recommended primary, first-line intervention to manage rotator cuff related shoulder pain (RCRSP). The results of this study suggest that a positive experience and outcome with exercise for RCRSP is contingent on several clinical contextual features, such as a strong therapeutic relationship. Thus, the clinical context within which an exercise program is prescribed and delivered should be considered by clinicians.

6.3 INTRODUCTION

Shoulder pain is a common and often disabling musculoskeletal pain condition (8, 231). In those afflicted, it impacts activities of daily living, sleep, physical and emotional function, and participation in valued activities (11, 231). Rotator cuff related shoulder pain (RCRSP) is a clinical term introduced in 2016 (42) and structurally refers to the muscles, tendons, and surrounding structures, such as bursae, bone, ligament, capsule, nerve, and their concomitant vascular tissues. RCRSP is the most common musculoskeletal shoulder condition and presents as shoulder pain and weakness, most commonly during shoulder elevation and external rotation (8, 42). RCRSP was introduced to avoid problematic pathoanatomical diagnoses such as subacromial impingement syndrome and non-traumatic rotator cuff tears. Internationally the term RCRSP is preferred over subacromial pain syndrome (SPS) (45), which refers to an anatomical location that is difficult to comprehend.

Both exercise therapy and education are recommended as the principal non-surgical approach for managing RCRSP (74). This is reflected in evidence-based clinical practice guidelines, where exercise therapy is the only treatment featured in all hitherto guidelines for RCRSP (76, 78). Exercise therapy results in comparable outcomes to more invasive treatment options, such as rotator cuff repair (48) and subacromial decompression surgery (257), corticosteroid (61) and platelet rich plasma injections (258). However, it must be acknowledged that exercise is far from a panacea for RCRSP (178). Ultimately, it is the clinician and patient, together in partnership, that is tasked with devising an agreed treatment plan, and this may include an exercise program.

There exists modest evidential support for exercise therapy to manage RCRSP (101, 103, 156), however, despite a high volume of research testing various combinations of exercise programs, the causal mechanisms underpinning the effect of exercise are largely unknown. Moreover, the clinical conditions (context) that promote or inhibit possible causal mechanisms has received inadequate attention.

Previous qualitative research endeavours exploring RCRSP have focused on the impact of diagnostic labels (36), patient beliefs about the cause of their shoulder pain (259), general experiences with exercise (260, 261), barriers and enablers to exercise (262) and the biopsychosocial impact of living with RCRSP (263). An in-depth exploration of the causal explanations expressed by individuals with lived experience of RCRSP about how exercise may have helped them, or not, is missing. Furthermore, knowledge is lacking about the clinical conditions that could trigger or hinder the activation of said causal mechanisms. Acquiring first-person perspectives about causal explanations of exercise may help clinicians understand how an individual with RCRSP might comprehend the utility of an exercise program and identify the clinical conditions that could maximise the benefits of an exercise regimen. Commonly proposed causal explanations could subsequently be tested in quantitative research, perhaps using mediation analysis. As such, this study aimed to gain insights into how individuals with RCRSP believed exercise helped their shoulder pain and identify the clinical conditions that promoted or inhibited this.

6.4 METHODS

6.4.1 *Design*

A qualitative study using in-depth semi-structured interviews conducted in accordance with the Standards for Reporting Qualitative Research (SRQR) (264).

6.4.2 *Qualitative approach and research paradigm*

This qualitative research investigation was underpinned by a critical realist philosophy (145). Critical realism is a philosophy of science that integrates a realist ontology, which posits there is something real in the world to find out about, with a relativist epistemology, which is based on the premise that individuals will come to know different things in different ways (265, 266). Using a critical realist approach to thematic analysis is thought necessary when the primary research question seeks a causal explanation to a particular event or experience (267). The purpose of a critical realist approach to thematic analysis is to produce the most plausible explanations of the mechanisms that cause events or experiences. A critical realist approach to thematic analysis follows a five-step process, where it is possible, and encouraged, to move freely back and forth between the steps (267). These steps are explicated in detail in the following sections.

6.4.3 *Researcher characteristics and reflexivity*

Lead investigator (JKP) is an Australian trained physiotherapist and PhD candidate with 12 years clinical experience, who has a particular interest in the assessment and management of

musculoskeletal shoulder disorders and who has received training in qualitative research. NC is a musculoskeletal researcher who has a PhD in physiotherapy and draws from both social science and public health lenses when conducting qualitative research. Fellow investigators (BS, WH, and JL) are experienced researchers and musculoskeletal clinicians with extensive experience in both quantitative and qualitative research methods, each with more than 100 scientific publications. We recognise that the results presented here are informed by our multiple and varied positionalities.

6.4.4 Data collection methods

The lead investigator (JKP) conducted 7/11 interviews and NC conducted 4/11 interviews. All but one interview was conducted via Zoom™ video conferencing software. The remaining interview was conducted over the telephone using audio recording only as the participant did not like using Zoom™. Investigators and participants engaged in the interviews predominately from a home setting, and on some occasions from their work setting. In all cases interviews were conducted one to one with a single investigator. Video and audio interviews were chosen to limit the constraints of geographic location and because this is often the preferred method of participants (268). Data collection commenced August 2nd, 2022, and ended December 5th, 2022.

6.4.5 Sampling strategy

Participants were eligible to participate in this study if they met the selection criteria outlined in Table 8.

Convenience sampling was used to recruit participants via the social media platforms Instagram™, Facebook™, and Twitter™, and who presented to the lead investigators (JKP) clinical practice. As some participants were known to the principal investigator as former patients, a co-investigator (NC) interviewed them. Purposive sampling was used to facilitate an even representation of sex, and diversity in terms of duration of pain and occupation. As a research group, we acknowledge the ongoing debate regarding when to stop recruitment, as problems have been identified with the traditional ‘thematic saturation’ concept (269, 270). We opted for theoretical sufficiency as an alternative approach to ceasing data collection. Such an approach emphasises how meaningful the data appears, with the view that if it adds no new perspectives and understandings to the topic explored it is reasonable to infer that an appropriate sample size has been achieved (270, 271).

Table 8: Selection criteria

Inclusion criteria	Exclusion criteria
Aged 18 and above	Had previous shoulder surgery on the affected arm within 12 months of diagnosis of RCRSP
Have had an episode of shoulder pain lasting more than 1 month	Has a known inflammatory disorder (such as rheumatoid arthritis)
Have been assessed by a registered health care professional and been given a diagnosis of rotator cuff related shoulder pain, which includes rotator cuff tear (full or partial thickness), rotator cuff tendonitis/tendinopathy/tendinosis, shoulder impingement syndrome, and subacromial bursitis).	Had a fracture on the affected arm within 12 months of diagnosis of RCRSP
Have engaged with a rehabilitative exercise program as prescribed by a registered health care professional	Had been diagnosed with frozen shoulder within 12 months of diagnosis of RCRSP
Has proficiency in written and spoken English	Had known glenohumeral joint osteoarthritis at the time of diagnosis of RCRSP
	Had displayed evidence of calcific tendinopathy within 12 months of diagnosis of RCRSP
	Had a history of shoulder dislocations or subluxations on the affected shoulder
	Had displayed signs and symptoms of cervicogenic shoulder pain and cervical radiculopathy within 12 months of diagnosis of RCRSP
	Had any condition of the arm/shoulder/nervous system that restricts being able to exercise it

Table 9: Participant information

Participant (Pseudonym) Sex, Age (years)	Occupation	Nationality	Duration of symptoms	Diagnosis	Health care professions consulted	Treatments trialled	Imaging received
Luke Male Age 32	Maintenance professional	Australian	10 months (ongoing)	Rotator cuff tendinopathy, subacromial bursitis and shoulder impingement syndrome	General Practitioner Physiotherapy	Rest and exercise-based rehabilitation	X-ray and Ultrasound
Kevin Male Age 31	Business owner	Australian	18 months (ongoing)	Partial thickness rotator cuff tear and subacromial bursitis	Physiotherapy	Rest, dry needling, exercise-based rehabilitation	MRI
Claire Female Age 36	School teacher	Australian	60 months (ongoing)	Rotator cuff tendinopathy and partial thickness tear and subacromial bursitis	Osteopathy General Practitioner Physiotherapy	Massage, dry needling, rest, ice, and heat pack, NSAIDs, exercise-based rehabilitation	X-ray and Ultrasound
Bill Male Age 31	Electrical Engineer	Australian	36 months (recovered)	Shoulder impingement syndrome and subacromial bursitis	General Practitioner Physiotherapy Massage therapy Chiropractic Exercise physiology	NSAIDs, massage, dry needling, chiropractic adjustments, exercise-based rehabilitation	X-ray, Ultrasound, and MRI
Max Male Age 52	General manager	Australian	9 months (ongoing)	Rotator cuff tear and subacromial bursitis	General Practitioner Physiotherapy Osteopathy	Ice, massage, exercise-based rehabilitation	X-ray and Ultrasound
Jessica Female	Student	South African	16 months (ongoing)	Rotator cuff tendinopathy and subacromial bursitis	Orthopaedic surgeon Physiotherapy	Manual therapy, exercise-based rehabilitation, and NSAIDs	MRI

Age 25					Biokineticist		
Matthew Male Age 33	Strength and conditioning coach	Australian	24 months (recovered)	Shoulder impingement syndrome	Physiotherapy Chiropractic Exercise physiology	Manual therapy, dry needling, chiropractic adjustments, and exercise-based rehabilitation	Nil
Ella Female Age 65	Retired	American	5 months (ongoing)	Shoulder impingement syndrome	Physician assistant Physiotherapy	Exercise-based rehabilitation	X-ray
Charlotte Female Age 26	Student	Canadian	132 months (ongoing)	Rotator cuff tendinopathy	Physiotherapy Massage therapy Chiropractic	Manual therapy, chiropractic adjustments, therapeutic ultrasound, and exercise-based rehabilitation	Nil
Lisa Female Age 34	Nurse	Australian	6 months (recovered)	Rotator cuff tear and subacromial bursitis	Orthopaedic surgeon Physiotherapy	Ice, analgesics, manual therapy, and exercise-based rehabilitation	MRI and Ultrasound
John Male Age 27	Personal trainer	German	4 months (ongoing)	Subacromial bursitis and rotator cuff tear	Sports physician General Practitioner Physiotherapy	Exercise-based rehabilitation, percussive therapy, cupping, massage therapy, NSAIDs, topical heat cream	X-ray and Ultrasound

6.4.6 *Ethics*

Ethical approval for this research project (project number JP03070) was obtained by the Bond University Human Research Ethics Committee. All participants provided written informed consent prior to interview.

6.4.7 *Pilot interview*

A pilot interview was recorded with an individual with a history of RCRSP, which lasted for 29 minutes. The pilot interview led to the refinement of language and structure of questions in the interview guide.

6.4.8 *Data processing and analysis*

The interview audio files were transcribed verbatim using the digital platform [Rev](#). Transcripts were checked for accuracy against the original audio file, anonymised using pseudonyms and deidentified of relevant geographical locations, and subsequently uploaded to the electronic data management software, NVivo, for commencement of data analysis. For data analysis we followed the five-step critical realist approach to thematic analysis as described by Fryer, 2022 (267). Investigators JKP and NC independently read the first three transcripts with the research question in mind, and then met to develop preliminary codes. NC then coded three of the transcripts and JKP coded eight. JKP developed the causal explanations captured in our codes (267), which were discussed with the research team. The development of causal explanations employs retroductive reasoning, which allows for inferences to be made about what best explains a particular event or experience (266).

6.4.9 *Techniques to enhance trustworthiness*

We took several steps to enhance the trustworthiness and rigour of this qualitative research investigation. First, we had multiple interviewers (JKP and NC) and coders (JKP and NC). We then had an additional investigator (BS) review and verify these codes against the original transcripts. One investigator (JKP) developed and refined the causal explanations in constant consultation the research team. To enhance the credibility of data analysis and participant involvement, refined causal explanations were sent to study participants for an opportunity to provide feedback or request a modification (270, 272).

6.5 RESULTS

Twenty participants volunteered for this study, with 9 participants unable to meet the selection criteria (8 did not fulfill the clinical presentation of RCRSP, and 1 did not perform an

exercise program). Eleven participants with RCRSP (6 male, 5 female) with a mean age of 36.5 years and median symptom duration of 16 months were enrolled in the study. The participants were from Australia (7), Canada (1), the United States (1), Germany (1), and South Africa (1). Further participant details are provided in Table 9. The average interview duration was 37 minutes (range 27-45 minutes). A decision was made to cease data collection when the final 3 interviews did not modify existing coding categories (theoretical sufficiency), and the data hitherto obtained was rich in depth and judged to add no new perspectives to the topic investigated. All participants were given the opportunity to review preliminary findings. Participants were satisfied that their individual experiences and perspectives were captured in the results of this study. Overall, exercise therapy was perceived to be a beneficial treatment for RCRSP, under certain conditions:

6.5.1 Condition 1: A strong therapeutic relationship is the foundation for a clinical improvement with exercise therapy

All participants stressed their relationship with their treating clinician played an important role on their engagement in, and improvement through, exercise (Table 10). Based on participants responses, a strong therapeutic relationship built on trust, collaboration, reassurance, and empathy seemed to be the foundations for a positive experience with exercise. Conversely, a clinical interaction devoid of a strong therapeutic relationship, primarily because of poor communication or a lack of trust, meant that exercise could not contribute to a clinical improvement in shoulder pain or function, either because the patient would seek a different therapist or would not do the exercises. Our interpretation from participants' experiences is that the relational aspects of musculoskeletal health care can influence whether an exercise program is able generate a positive clinical outcome (such as reduced shoulder pain) and highlights the importance of the patient-clinician relationship. Thus, we propose the causal power of an exercise program to positively influence shoulder symptoms is conditional upon a strong therapeutic relationship between the clinician and patient

Table 10: Supporting quotes of clinical conditions that promoted or inhibited the success of an exercise program for an individual with RCRSP

Condition 1: A strong therapeutic relationship is the foundation for a clinical improvement with exercise therapy
<i>"I think just with the relationship that I built with my physio and I knew that whatever he said I needed or didn't need, and I trusted his advice, I trusted his education, and how we, I guess, just had that therapist and patient relationship. It was very, very comforting" (Charlotte).</i>
<i>"So I think that was really good too, because I got a much more trusting relationship [with the therapist], that they were just genuinely more interested in me trying to build long term strength and health rather than a repeat customer to some extent." (Bill).</i>
<i>"The way that it was communicated, it didn't really fill me with confidence that there was a lot of buy-in to getting me out the other end, and I'd say as quickly as possible, because that my motivation was to get out the other end quickly." (Max).</i>
<i>"I never really liked the physio or the head of physio... He was very dismissive in general with a lot of conditions, especially anything to do with CrossFit. So when I went in and got seen, I didn't get a lot of, I guess, interest. It was like, "Oh, another person with shoulder pain" ... And that's when I went to the next physio." (Matthew)</i>
<i>"She could temper it in a positive way by telling me how far I've come. "That's normal. You're working those muscles, that's normal. It's got to be sore." And so she always normalized everything for me. I'd always get really concerned I was making it worse.</i>
Condition 2: The exercise program should be structured and tailored to the individual clinical presentation
<i>"And again, it seemed a little like it's a generic document and stuff like that, so you sort of look at it and think, it's just the same as lots of other people, whether it's good or bad." (Max).</i>

"Yeah, it felt like it was a more tailored approach to me about me getting better as opposed to just a cookie cutter; here's a default program for six to eight weeks that should make you better. Everyone does the same thing approach" (Bill).

"He guided me through not only with the exercises and giving me a trajectory, which was fantastic, because I really like planning and structure so what it's going to look like in a month's time, what it's going to look like in two months' time" (Lisa).

"Probably relieved to have a bit of guidance, to have a plan. Because although I haven't had any success, long term success with any of the treatments I've done, but just have a plan and someone to check in with fortnightly or monthly. So I felt like it was good and I'm held accountable". (Claire).

"So if something felt too easy, I'm like, Ah, is it of benefit if it feels too easy, or if there's pain there, is that an issue or not... But at the time, I still felt like I was on my own to figure it out, and he didn't provide a follow-up appointment or anything. It was more just, "Yeah, do this for a couple weeks. Your shoulder will be fine. If it's not fine, then we can chat later." But there was no the check-ins scheduled or anything." (Kevin).

Condition 3: Timely clinical progress with exercise therapy matters

"Okay, I can see the progress, I can see what's happening with my shoulder." (Charlotte).

"What really helped absolutely in me not giving up, of course, is seeing progress." (John).

"It's been four or five weeks, I'm already feeling an improvement in that now, I can demonstrate to you and I don't have that same twinging, sharp impingement pain. And I put that down to the exercise that I've been doing religiously for the last five weeks. So that's had a better outcome for me than the osteo treatments. (Claire).

“But anyway, I like the exercises even though at first they made me very sore. When I stuck with them I was like, “Oh my gosh, I can go further, higher, longer.” Then we would increase the resistance, we would increase the band resistance, how they have really light ones and they get heavier, so we could increase those.” (Participant Ella).

“And then once I started building up [strength], I started getting confidence”. (Lisa).

“I had 80% strength when I first saw the physio and did that initial consultation and then probably after three or four months, I probably only had 30 or 40% strength in my shoulder... So, yeah, that was very frustrating after a while because I was like, oh, I am doing these [exercises] properly. And then it probably got to the point where I was kind of like, well, does it really matter if I don't do it [exercise] tonight, or if I don't do it tomorrow, and I found [it] really hard to then motivate myself to stick to that same pattern of programming and exercises.” (Bill).

“Even though I've seen progress and she's [clinician] positive and I loved working with her and we had a connection, to me I'm still not back playing pickleball yet. I'm still not back to doing all the things I usually do”

6.5.2 Condition 2: The exercise program should be structured and tailored to the individual clinical presentation

Participants often believed that receiving an exercise program that was tailored to their individual clinical presentation was necessary for their clinical improvement (Table 10). Some participants expressed dissatisfaction and scepticism when provided with a seemingly generic exercise program that was not believed to be fit for their purpose. This subsequently affected their engagement and belief in the exercise program, which may have impacted on their clinical outcomes.

Participants frequently reported that an exercise program that was carefully planned and had a logical structure was important to them. Having a plan and structure enabled participants to imagine their possible trajectory over time and gave them something real and tangible they could regularly engage with. This created a feeling of accountability for some participants and may have incentivised continued engagement with the exercise program. When an individualised exercise plan was lacking, this resulted in a feeling of being ‘left alone’. Based on participants responses, an exercise program that is structured and tailored to the individual is an important precondition for exercise to be beneficial for individuals with RCRSP.

6.5.3 Condition 3: Timely clinical progress with exercise therapy matters

The concept of experiencing “timely progress” was an important feature of exercise therapy for most of the participants (Table 10). Experiencing timely progress often reinforced to participants that the exercises they were doing were beneficial, thus incentivising continued adherence to the exercise program. What constituted progress was varied, but most often included references to increased shoulder strength (e.g., lifting more weight or doing more repetitions of the same weight), pain reduction, improved shoulder range of motion (ROM), and the ability to engage with valued recreational pursuits, such as surfing and pickleball. One participant expressed that while they were happy with gaining shoulder ROM and strength, and experiencing less pain, their ultimate goal was to return to pickleball. Progress in psycho-emotional states, such as confidence, were also mentioned. Any obvious improvement in physical measures of the shoulder, feelings of confidence using the shoulder, or the ability to perform a certain physical recreational activity were important metrics that participants used to gauge their progress. When no discernible progress was experienced, doubt and apathy about the particular exercise program ensued. Thus, if an exercise program failed to elicit a demonstrable change in participant signs and symptoms in a timely fashion, this affected the causal power of the exercise program. The presence of a strong therapeutic

relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress were the clinical conditions that promoted positive experiences and outcomes with an exercise program. From the participants experiences, we were able to generate 3 causal explanations for the positive clinical outcomes:

6.5.4 Causal explanation 1: Shoulder strength influences clinical outcomes

Most participants reported that increasing shoulder strength or engaging in strengthening exercise was a decisive factor for their positive experience and improvement with exercise therapy (Table 11). Some participants reported they enjoyed the feeling of becoming stronger despite using light weights, while others expressed feeling frustrated when an exercise program was not perceived to be challenging enough. On occasions when a strengthening program was not provided by the treating clinician, this was met with scepticism and doubt. Meanwhile, other participants expressed surprise that their treating clinician encouraged them to try a strengthening-based exercise program and that it was able to produce an improvement in symptoms. There was a belief from some participants that a stretching-based exercise approach or a form of manual therapy was needed for their RCRSP, in part based on past experiences with health care professionals and doing their own research. However, the surprise was often well met by participants, particularly if the treating clinician was able to appropriately explain why they were recommending said treatment approach. Some participants also expressed that continuing to engage in shoulder strengthening exercise was important for optimising long term shoulder health and the prevention of shoulder pain flare ups. One participant reflected on their journey of getting stronger and progressing with their exercise program, but without an associated improvement in pain. This participant felt reassured by their strength gains and simultaneously disappointed that this development of shoulder strength did not eradicate their pain. Taken together, shoulder strength was the dominant causal explanation for a positive experience with exercise therapy according to this cohort of individuals with lived experience of RCRSP.

Table 11: Supporting quotes of causal explanations for a positive experience with exercise therapy

Causal explanation 1: Shoulder strength influences clinical outcomes
<i>“It's great. I could just feel myself getting stronger even though I'm using two kilo[gram] dumbbells. It's really light, but I just love it.”</i> (Claire)
<i>“And then the second I started strength training, I felt, yeah, just doing one exercise, every part of my shoulder was engaged. I was feeling that instant connection between the exercise I was doing and a positive improvement in my shoulder”. (Bill).</i>
<i>“And so I felt that that's what I was doing. I felt those exercise bands or exercises were working muscles I hadn't used in a long time properly.” (Ella).</i>
<i>“So he did the dry needling and then I just grilled in with questions after. I'm like, what's now? Am I going to get a strengthening program, and what are your thoughts, what do you think this is? When can I get back to activities, when can I do this? (Kevin).</i>
<i>“I didn't feel like that was actually building any sort of strength or stability in my shoulder. There were exercises that, they were isolating the muscles that they were trying to do, but overall I wasn't building any sort of strength or resistance to an actual weight that I would be using in real life” (Bill).</i>
<i>“The strengthening exercises got rid of my pain. It was really bizarre process to me because I thought these sorts of pain things would need stretching, and definitely, I could never lift weights again, and starting to lift weights slowly and doing certain things, like increasing my range in my shoulder with the strength exercises, the pain would just go.” (Lisa).</i>

<i>"I was not expecting him to be taking me to do dumbbell weights. I thought it was different, but I was open to suggestion because I guess he was really confident about it as well. He's like, "You're weak, this will help.""</i> (Claire).
<i>"So, even as I progressed strength wise, and I could do heavier things, more complicated things, that same pain would just stay throughout the whole progression [of exercise] ... So, that was sort of a bit of, I felt let down by the universe rather than be let down by the exercise, because I was like, "I'm doing this exercise, and it's worked so, so well for everything else. Why is it not working for this?""</i> (Jessica).
<i>"So if I had a period where I didn't go to the gym for three or four weeks or something like that, and then something else happened that was generally when I then instantly start to feel that I was susceptible, if you like, to having more of an underlying issue. But as long as I was maintaining that consistent strength training, yeah, I haven't had any issues since with my shoulders, which has been really good".</i> (Bill)
Causal explanation 2: Exercise therapy influences psycho-emotional status
<i>"But obviously the exercise was important, like I said, for my mental state, to know that I was still physically capable of doing stuff".</i> (Max)
<i>"Just restoring that faith in my shoulder, I suppose, which is what he got me to eventually do with all of the strength exercises".</i> (Lisa)
<i>"I went crazy Googling it [bursitis] and it was telling me rest, rest, rest... And I think mentally, if the pain is coming from moving my arm, then I would just stop moving my arm and it wouldn't give me as much grief, but it was limiting my ability to do things... I hadn't read anything online about going and getting two and three kilo dumbbells to fix a shoulder injury... It was almost, it felt good to push through</i>

the discomfort [when exercising shoulder], knowing that it was for the best, if that makes any sense. So even though it wouldn't feel the same on both sides, it would feel discomfort and a bit twingey just being told by one person that it's [exercise] actually not going to hurt me, I was happily able to continue it and know that was for the best... It was more of a mental thing than it was physical.” (Claire)

“So I was very nervous at first [doing shoulder exercises], but I mean, he was watching and walking, doing a 360 and, I guess, checking to see how things were moving. And then when I realized that it wasn't shooting pain... I think I just kept saying... I kept saying, "I can't believe I'm doing this. I never thought I'd be doing this again." is what I kept saying to him... "Wow, I can't believe it." It was almost like it was good. It was having a little mini personal training session because I never thought I'd have that range or the ability to do that again.” (Claire)

“Even though I was doing all the exercises and gaining strength and things, I still didn't trust myself to do bodyweight exercises...I thought for some reason it [shoulder] would just buckle, but I had exercises building me up to that plank...and then anyway, I eventually got to a plank towards the end, and that's amazing, and look how far I've come”. (Lisa).

“But yeah, I did that [exercises] for a couple of days and it seemed to just take away that fear of using my shoulder and just give me a little bit more confidence that it was sort of working best again”. (Max)

Causal explanation 3: Exercise therapy has widespread positive health effects

“It's a positive. It's beneficial. Feels good [exercise]... Obviously exercise is a good thing, if done right. It's good for joints. It's good for muscle. It's good for tendons. It's good for ligaments. It's good for strength. It's good for mental health”. (Luke)

“They [exercises] always feel good because it feels like I'm eating a healthy meal or doing a sporting activity. It feels like you're doing something to get better... So I've always put them as this is something that's good for me, so I get a feeling of achievement at the end of it and I'm doing something good for my body”. (Kevin)

But obviously the exercise was important, like I said, for my mental state, to know that I was still physically capable of doing stuff. But also obviously using it and moving it is probably good for the muscles and keeping things in as best condition, I guess, they could be in. (Max)

6.5.4 Causal explanation 2: Exercise therapy influences psycho-emotional status

Participants frequently articulated the benefits of exercise were in part due its influence on their thoughts and feelings (Table 11). In some instances, exercise helped to build or regain trust in their shoulder and also override beliefs that pain during shoulder exercise means it is damaging for their shoulder. There was a tendency for participants to think that rest was the preferred strategy for managing RCRSP, a belief derived mostly from doing their own research. This strategy of rest would sometimes lead to participants over-protecting their shoulder by avoiding basic shoulder movement and exercise. However, engaging in therapeutic exercise that exposed an individual to a movement or exercise that carried an expectation of pain or vulnerability was helpful to change their beliefs about their shoulder pain and capacity. Some participants reported that exercise helped increase confidence in their shoulder, which was sometimes accompanied by reduced fear of using their affected shoulder. Thus, according to participants in this study, the benefit of exercise for RCRSP goes beyond its biomechanical effects and influences the psycho-emotional status of individuals.

6.5.4 Causal explanation 3: Exercise therapy has widespread positive health effects

Exercise was often believed to be an intrinsically good activity to engage with due to its varied positive influence on general health (Table 11). Exercise was often thought of as a healthy behaviour, like eating a nutritious meal, and having multi-system benefits that go beyond the shoulder. This helped the perception of exercise therapy as a beneficial and productive treatment. This may also have helped participants continued engagement with exercise, comfortable in the knowledge that even if exercise didn't help their shoulder pain specifically or substantially, at least they had done something generally positive for their health. The productive nature of exercise and its perceived capacity to have widespread positive health effects was a common causal explanation for a positive experience with exercise.

6.6 DISCUSSION

This study aimed to gain insights into how individuals with RCRSP believed exercise helped or didn't help their shoulder pain and identify the clinical conditions that promoted or inhibited this. Whether exercise caused a positive clinical improvement was conditional on certain contextual factors: the presence of a strong therapeutic relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress. If these conditions were partially or fully satisfied, exercise therapy consistently produced an improvement in shoulder pain and function, most commonly via the causal explanations: increase in shoulder strength, a

positive change in psycho-emotional status, and widespread positive influences of exercise on general health.

Most participants in this study expressed their relationship with their treating clinician was a key part of their experience of engaging with an exercise program for their shoulder pain. A suboptimal or strained therapeutic relationship often led to a poor experience with exercise and the subsequent pursuit of a different health care professional. Conversely, a strong therapeutic relationship was often the foundation for a positive experience with exercise. Thus, the causal power of an exercise program depended on the relationship and interaction between the clinician and individual seeking care, and the better the relationship, typically the better the experience with exercise. The value of a strong therapeutic relationship across diverse non-traumatic musculoskeletal conditions has been discussed in the literature. People with lived experience of patello-femoral pain (PFP) (273), knee osteoarthritis (274), non-specific low back pain (275), RCRSP (276), and greater trochanteric pain syndrome (277) consistently express that a trusting, empathetic and united relationship between themselves and their treating clinician is an integral component of their care. This seems to extrapolate to clinical outcomes too, with evidence reporting a strong therapeutic relationship is associated with improved clinical outcomes (278). Crucially, a strong therapeutic relationship may facilitate better adherence to a prescribed exercise program (279, 280). Taken together, we conjecture that even the best exercise program might lack causal power in the absence of a strong therapeutic relationship. Thus, we urge clinicians to take time to build this relationship before rushing to provide their expertly crafted exercise program.

Participants who were dissatisfied with a particular exercise approach often lamented that their exercise program was generic and not tailored to their individual goals and needs. A desire for individualised exercise prescription reported in this study is similar to previous qualitative research evidence for PFP and non-specific low back pain (281). The desire for a tailored approach to exercise prescription for RCRSP is supported by empirical data which suggests there is no universal best exercise approach (105, 282, 283). Therefore, rather than decreeing one particular exercise approach as superior, clinicians should endeavour to construct an exercise program in close collaboration with the individual in question and with careful consideration of access to equipment, past experiences with exercise, beliefs about exercise, and their individual goals.

Experiencing timely clinical progress with an exercise program was important for most participants. Most of the time, progress took the form of an improvement in shoulder strength or the experience of less shoulder pain with a particular movement, which aligns with previous qualitative research in the area of non-specific low back pain (281). Similar to the work of Littlewood et al

2014 (261) a lack of timely symptom improvement was met with suspicion and doubt about the benefit of a particular exercise program, which affected motivation and adherence to the exercise program, ultimately leading to poor clinical outcomes. Given recovery from RCRSP with exercise is not usually a quick process, in some cases it is recommended that 12 months of exercise therapy be trialled prior to escalating treatment to more invasive treatments (284), the desire for a timely improvement in shoulder symptoms by patients with exercise may prove difficult. Therefore, we encourage clinicians and patients to have open and honest conversations about possible recovery timeframes. Clinicians should consider incentivising patients to continue with a particular exercise approach by tracking changes in shoulder strength and ROM, using outcome measures that assess ability to perform valued activities (such as the Patient Specific Functional Scale (285)), and use general patient reported outcome measures to objectively gauge clinical progress.

The dominant causal explanation of participants in this study for a positive experience with exercise for RCRSP was a perceived improvement in shoulder strength. This finding is concordant with causal explanations proffered by clinical trialists (234) and practising physiotherapists (45) for the beneficial effect of exercise for RCRSP. Outside of the shoulder, a similar theme is reported for the effect of exercise for non-specific low back pain (181) and knee osteoarthritis (184). Taken together, the prevailing view of researchers, clinicians, and individuals with lived experience of RCRSP, is that ‘getting stronger’ is the key mechanism underpinning the benefits of exercise therapy for RCRSP. This is despite there being no empirical support that shoulder strength is a mediator of outcomes for individuals with RCRSP (170). It remains biologically plausible that shoulder strength is causally linked to positive clinical outcomes in people with RCRSP, based on evidence which shows that quadriceps strength mediates improvements in pain and physical function in individuals with knee osteoarthritis (247). Therefore, the biological plausibility and consistent reports from different stakeholders of the importance of shoulder strength means it is a casual explanation researchers and clinicians should take seriously (132, 138). Another advantage of using shoulder strength as a useful heuristic to causally explain the effect of exercise for RCRSP is it is a cogent word that individuals with varying degrees of health literacy could understand. Clinicians should cautiously consider using shoulder strength as a valid and comprehensible causal explanation for the beneficial effect of exercise. Further research is required to strengthen this proposal.

Various psycho-emotional states were expressed by participants as being influenced by exercise therapy, including increased confidence and belief in their shoulders, reduced fear of shoulder movement, and reassurance that their painful shoulder was still able to perform basic

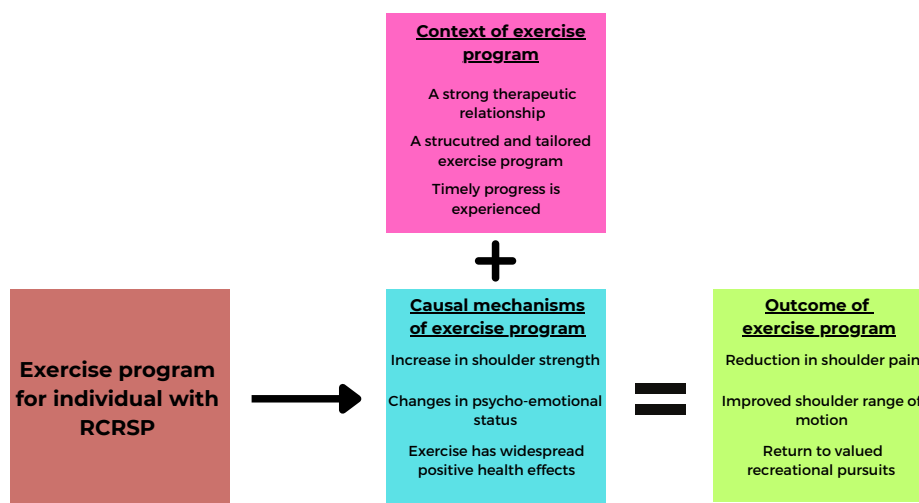
activities. Kinesiophobia and pain self-efficacy are associated with clinical outcomes in people with shoulder pain (241-243) however it is uncertain to what extent exercise can modify these constructs. Research on osteoarthritis has shown self-efficacy to be a mediator of clinical outcomes (244) and this could well be the case for RCRSP (245). There is also low-quality evidence that exercise training can effectively reduce fear avoidance beliefs in a predominately spinal pain cohort (cervical and lumbar spine) (286). Some participants alluded to experiencing a psychological phenomenon with exercise therapy that resembles expectancy violation. Expectancy violation (287) is a concept embedded within exposure therapy, which has been a mainstay of treatment for anxiety disorders for decades (288). When applied to musculoskeletal pain, expectancy violation represents the discrepancy between expected and experienced pain during a specific movement or task. It is theorised that a mismatch between expectation and experience is critical for new learning (288, 289) and the updating of possible unhelpful understandings about pain. Some participants in this study expressed surprise that they could lift a dumbbell weight without pain or that they could work up to doing bodyweight exercise despite initially not trusting their shoulder. This surprise or “expectancy violation” may have contributed to enhanced feelings of confidence in their shoulders and provided reassurance and motivation that they were on the right pathway to recovery. Based on the experiences of the participants in this study and also the current evidence base, we contend that various psycho-emotional states underpin a positive experience with exercise for RCRSP, and clinicians should consider building this into their education.

Participants in this study often acknowledged that exercise can positively influence multiple bodily systems. This sentiment agrees with an abundance of evidence reporting the positive association between exercise and general health and wellbeing (290-295). Exercise was often recognised as a fruitful treatment to engage with because of its healthy behaviour connotations, which may have led to perceived improvement in shoulder symptoms. Taken together, causal explanations for the benefit of exercise for RCRSP could involve references to the whole-body effects of exercise.

It is important to clarify that the causal mechanisms of exercise that led to a positive clinical outcome in this cohort of individuals with RCRSP were only triggered in the presence of an appropriate clinical context (Figure 14) That exercise has causal powers which depend on its manifestation partners (individual with RCRSP and clinician) is a novel theory when specifically applied to exercise and RCRSP but fits comfortably within established critical realism philosophy (296) and dispositionalist theories of causation (297-299). If we take this theory to its logical conclusion, there probably is no magical dose or type of exercise that will universally help all

individuals with RCRSP – because every individual will present with their own set of personal dispositions which may or may not respond to a particular exercise program and the prescribing clinician. Any exercise program for RCRSP has the potential to help one individual, harm another or have no effect (151). Person centred health care acknowledges the medical uniqueness of an individual, and it makes pragmatic and philosophical sense to use exercise therapy with this theory in mind (297).

Figure 14: The relationship between intervention-context-mechanism-outcome for individuals with RCRSP



6.7 LIMITATIONS

There are methodological considerations to this study which warrant attention. The sample size of eleven participants may be considered small from a quantitative research standpoint. However, it is important to emphasise this is an original qualitative research investigation and the sample size was derived by achieving theoretical sufficiency. The lead researcher was a novice interviewer but is an experienced musculoskeletal clinician well versed in communicating with people with shoulder pain, who also undertook training in qualitative research interviewing prior to commencing the study. All interviews were conducted via online video conferencing software, which could have affected researcher-participant rapport, although evidence does support the use of this method of interviewing (268). Furthermore, data was predominately collected from people from economically developed countries whose first language was mostly English. It is important to acknowledge and respect that navigating pain, healthcare and exercise for a particular

musculoskeletal pain condition is influenced by cultural aspects and thus the findings of this study may not be transferable to other sociocultural contexts. Future research efforts might consider replicating the research methods used in this study and applying to a cohort of individuals from economically developing countries.

6.8 CONCLUSION

In summary, the most common causal explanations for a positive experience with exercise in individuals with RCRSP were an increase in shoulder strength, changes to psycho-emotional status, and the belief that exercise has widespread positive health effects. However, these causal mechanisms were only activated in the clinical context of a strong therapeutic relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress. Clinicians should consider not just the exercise parameters of an exercise program but also the clinical context in which the exercises are prescribed.

CHAPTER 7: IS EXERCISE THERAPY THE *RIGHT* TREATMENT
FOR ROTATOR CUFF-RELATED SHOULDER PAIN?
UNCERTAINTIES, THEORY, AND PRACTICE

7.1 PREFACE

Chapters 3 through 6 of this thesis primarily explore the research question: how and why does exercise causally reduce shoulder pain and disability in individuals with RCRSP? The findings reported in these chapters indicate the prevailing view of clinical researchers, clinicians, and patients with lived experience of shoulder pain is that exercise therapy exerts its therapeutic effect via changes to shoulder muscle strength, motor control, and various psycho-emotional states. Interestingly, clinicians and patients tended to rate the importance of changes to psycho-emotional constructs much higher than clinical researchers. The mechanisms believed to underpin exercise therapy identified in this research programme have little empirical evidence in support of their validity and this remains a much-needed area of research. It is hoped this thesis has drawn attention towards this extensive knowledge gap, made progress towards minimising it, and is able to form a robust foundation upon which future research endeavours can be pursued.

In Chapter 7, we weave together the research conducted hitherto on causal mechanisms with the broader evidence-base regarding exercise therapy for RCRSP. This was achieved by undertaking a critical review of the shoulder literature to explore the value of exercise therapy for individuals with RCRSP by considering evidence of efficacy and effectiveness, the lived experience of individuals with RCRSP, causal mechanisms of exercise, and various exercise dosing parameters and their relationship with clinical outcomes. This chapter concluded by providing practical and theoretical considerations for using exercise therapy in clinical practice.

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7.2 ABSTRACT

Background

Exercise therapy is a popular non-surgical treatment to help manage individuals with rotator cuff-related shoulder pain (RCRSP) and is recommended in all clinical practice guidelines. Due to modest effect sizes, low certainty evidence, uncertainty relating to efficacy, and mechanism(s) of benefit, exercise as a therapeutic intervention has been the subject of increasing scrutiny.

Aims

The aim of this critical review is to lay out where the purported uncertainties of exercise for RCRSP exist by exploring the relevant quantitative and qualitative literature. We conclude by offering theoretical and practical considerations to help reduce the uncertainty of delivering exercise therapy in a clinical environment.

Results and discussion

Uncertainty underpins much of the theory and practice of delivering exercise therapy for individuals with RCRSP. Nonetheless, exercise is an often-valued treatment by individuals with RCRSP, when provided within an appropriate clinical context. We encourage clinicians to use a shared decision-making paradigm and embrace a pluralistic model when prescribing therapeutic exercise. This may take the form of using exercise experiments to trial different exercise approaches, adjusting, and adapting the exercise type, load, and context based on the individual's symptom irritability, preferences, and goals.

Conclusion

We contend that providing exercise therapy should remain a principal treatment option for helping individuals with RCRSP. Limitations notwithstanding, exercise therapy is relatively low cost, accessible, and often valued by individuals with RCRSP. The uncertainty surrounding exercise therapy requires ongoing research and emphasis could be directed towards investigating causal mechanisms to better understand how exercise may benefit an individual with RCRSP.

Key words

Physiotherapy, exercise, movement, shoulder pain

7.3 INTRODUCTION

Shoulder pain is both common and burdensome (5). While not everyone afflicted suffers to the same extent, evidence from qualitative research reveals the profound impact shoulder pain can have on many dimensions of life (11, 231). There are myriad causes of shoulder pain, the most common being RCRSP (8). RCRSP is an overarching diagnostic label that includes traditional pathoanatomical diagnoses such as rotator cuff tendinopathy, subacromial bursitis and rotator cuff tears, and can be tentatively posited when shoulder stiffness, instability, and sinister pathology is not suspected to be part of the clinical picture at the time of assessment (42). A recent study suggested that RCRSP was the preferred diagnostic term of clinicians over subacromial impingement syndrome, subacromial pain syndrome and rotator cuff tendinopathy (45).

Non-surgical management options to reduce the pain and disability associated with RCRSP include education, understanding pain, exercise therapy, life-style management, hands-on therapy, electrical modalities, taping, braces, dry needling, acupuncture, and injection therapy. Often, these are delivered in various combinations with each other. Despite the many treatment options, with approximately equivalent effects, clinical practice guidelines consistently recommend exercise therapy as the main treatment for RCRSP (76, 78).

Exercise and movement therapy are considered an essential component of physiotherapy practice and physiotherapists are justified in making claims of being movement experts (99). Physiotherapy management of individuals with RCRSP is an apropos example of this, with a recent study highlighting that 99% of surveyed physiotherapists around the world indicating they would use exercise to manage an individual with RCRSP (45). Despite physiotherapists broadly embracing exercise therapy, in both historical and modern contexts, the pre-eminent position of exercise for RCRSP (151, 178, 300), and other musculoskeletal conditions such as hip and knee osteoarthritis (139, 301, 302), has come under increasing scrutiny. Critics appropriately assert that exercise does not appear to be held to the same standards as other treatments, such as manual therapy, surgery, and acupuncture, when considering its modest effects and low certainty of evidence (101, 156), lack of demonstrated efficacy (104), and importantly uncertainty regarding the causal pathways through which it may confer a therapeutic benefit (234). Moreover, no evidence has emerged to define the best exercise approach (including exercise type, dose, level of supervision, duration etc.) for helping an individual with RCRSP (106, 303, 304). Any combination of exercise that has been investigated for RCRSP, produces at best, modest results.

This uncertainty represents a paradox for clinicians who, on one hand, are often denigrated for incorporating manual therapy into management, but are consistently advised to prescribe therapeutic exercise, with both interventions, provided in isolation or combination, associated with less-than-optimal outcomes (74). In this critical review we aim to lay out where the uncertainties of exercise for individuals with RCRSP exist and conclude by offering theoretical and practical considerations to help clinicians navigate the uncertainty of delivering therapeutic exercise in their practice.

7.4 EFFICACY AND EFFECTIVENESS

In order to establish the efficacy of a treatment, it is considered necessary to compare the experimental treatment (e.g. exercise) with a sufficiently similar control treatment (typically a sham/placebo treatment) (305). Only one high quality study (104) has compared a treatment package of manual therapy and exercise with a sham control (inactive ultrasound) for individuals with RCRSP and reported no significant difference in shoulder pain and disability after 11 weeks. At 22 weeks, the exercise and manual therapy group had a significantly greater improvement in shoulder pain and disability, but the difference was not clinically meaningful. This trial challenges the assumed efficacy of exercise for RCRSP. A criticism of this study is the comparator intervention, and considerable uncertainty exists if a detuned ultrasound machine is a sufficiently similar control for complex treatments such as exercise and manual therapy (305).

Exercise therapy appears to out-perform a no treatment or no exercise control; however the magnitude of this effect is generally modest (101, 156, 306) and the certainty of evidence is assessed to be very low to low. A systematic review and meta-analysis reported that progressive resistance exercise compared to no treatment or placebo confers a benefit of uncertain clinical importance for pain and function (156). The same review found that non-progressive and non-resisted exercise confers no benefit over no treatment, or placebo (156). Findings from a systematic review and network meta-analysis concluded that exercise had the most robust evidence of being an effective treatment for RCRSP when compared to other non-surgical treatments (103).

When compared with more invasive treatment approaches, such as injection and surgery, exercise fares well. For example, there is no clinically important difference between exercise therapy and subacromial decompression surgery and rotator cuff repair surgery (48, 257). Corticosteroid injections have a similar effect to exercise therapy (61, 178), however, there is uncertainty pertaining to the possible deleterious effects of corticosteroid injections on local

shoulder soft tissue (63). Furthermore, exercise therapy out-performs platelet rich plasma injection at short term follow-up and is equivalent at long term follow-up (71).

The main finding of a recent randomised control trial (RCT), not included in any of the aforementioned reviews, was that the addition of a specific motor control or strengthening exercise program to education did not enhance the clinical outcomes of individuals with RCRSP compared to education alone (151). Thus, the view that exercise is necessary for everyone diagnosed with RCRSP is challenged. Overall, exercise therapy demonstrates a modest effect of uncertain clinical importance when compared to a no treatment control, has no evidence of being superior to a realistic sham treatment, and for many, doesn't out-perform an education program. Exercise has comparable effects to shoulder surgery, and injections, and has the most robust evidence of effectiveness of common non-surgical treatment options.

7.5 SHOULD EXERCISE BE DELIVERED IN ISOLATION OR COMBINED WITH MANUAL THERAPY?

In an update of systematic reviews Pieters et al, 2020 (74) made 'strong' recommendations for exercise therapy as the first-line of treatment to help manage signs and symptoms of RCRSP. A strong recommendation was also made to combine exercise therapy with manual therapy in the short term. A more recent systematic review and meta-analysis reported no significant difference between exercise in isolation compared to exercise plus manual therapy at both short and long term follow ups for both shoulder pain and function (82). Since the publication of these reviews, a RCT has been published by Michener et al, 2024 (80) reporting there is an added long-term benefit to providing manual therapy in conjunction with an exercise program compared to an exercise program alone. It is unclear the mechanism underpinning the possible added benefit of manual therapy to an exercise program, as highlighted by another recent RCT which reported no between group differences between sham manual therapy and real manual therapy, when added to an exercise program (307). Thus, one could speculate that any added benefit of manual therapy might be due to contextual effects. Based on current evidence, exercise could be delivered either in isolation or in conjunction with other therapies, such as manual therapy, and this will depend on shared decision making (308).

7.6 IS THERE AN OPTIMAL EXERCISE APPROACH?

“The history of medicine has never been a particularly attractive subject in medical education...virtually anything that could be thought up for the treatment of disease was tried and, once tried, lasted decades or even centuries before being given up” (309)

The history of physiotherapy is punctuated with the rise, fall, and stagnation of various exercise approaches for managing musculoskeletal pain. Hypotheses exist that have been purported to support stretching, strengthening, movement performance, motor control exercise, breathing and relaxation exercises for managing various musculoskeletal pain conditions, RCRSP included. At this juncture it is arguably correct to state there is no one best exercise approaching for managing individuals with RCRSP (303, 304).

Here we explore common variables physiotherapists consider when constructing exercise programs for individuals with RCRSP and examine their influence on clinical outcomes.

7.6.1 Is there a superior exercise type?

The selection of an exercise type (e.g. resistance exercise, motor control exercise, and stretching exercise) to manage an individual with RCRSP poses a conundrum for clinicians. There are many exercise approaches available to help an individual with RCRSP, and it is typical to see two or more different approaches combined together in the same program (234). In this review, we focus on two of the most popular exercise approaches for RCRSP; progressive resistance exercise and motor control, or movement facilitation exercise (45, 234). The most current meta-analyses report no sustained significant difference between specific motor control exercise and general resistance exercise for RCRSP (105, 282). A recent three-arm RCT not included in the latest meta-analyses corroborates these findings, reporting no significant differences between education alone, education and motor control exercise, and education and resistance exercise in clinical outcome (151). Given the apparent equivalence of the two most common exercise types, perhaps it is more useful to consider when a particular exercise approach might be more appropriate for an individual based on their preferences and symptom profile. Under this framework, clinical decisions about exercise type will depend more on the symptom irritability and preferences of an individual, rather than a preconceived bias to favour one exercise approach over another, allowing clinicians to move fluidly between exercise types as the clinical situation dictates (90).

7.6.2 Does the exercise dose make the poison?

Exercise dose (volume) is described by the load lifted, the number of repetitions, and the number of sets of repetitions (310). Malliaras et al. 2020 conducted a systematic review comparing higher versus lower dose resistance exercise for RCRSP and found low to very low certainty evidence that higher dose resistance exercise confers superior functional outcomes compared to lower dose exercise (106). It must be noted that this review only included three RCTs in its analysis and was clear in stating their results didn't support the claim that higher dose resistance exercise

was better than lower dose resistance exercise. Since the publication of the Malliaras et al. 2020 review, a RCT exploring exercise dose for RCRSP has been published by Clausen et al. 2021 (179) and reported that adding a large dose of resistance exercise to usual care did not provide any additional benefit for individuals with RCRSP. However, in a pre-defined secondary analysis, Clausen et al. 2023 reported that the level of baseline pain catastrophising modified the effect of the extra dose of resistance exercise (311). Those with lower baseline catastrophising benefited more from an extra dose of resistance exercise, whereas those with higher catastrophising scores actually tended towards an unfavourable outcome. Another recent RCT, not included in the Malliaras et al. 2020 review, similarly reported no significant difference between a progressive higher load resistance exercise regimen and a lower load program (312). For tendinopathy in general (including studies pertaining to RCRSP), it has been reported that resistance exercise with an external load, compared to body weight only, is more effective (313), perhaps increasing credence that some external load is better than none.

Uncertainty surrounds how often exercises should be performed (frequency) and the optimal duration of an exercise program, with different frequencies and durations leading to beneficial effects for individuals with RCRSP (304). The available evidence indicates, with the possible exception of those with low levels of pain catastrophising, the absence of a consistent dose-response relationship between exercise dose and clinical outcomes for individuals with RCRSP. Individual treatment goals, stage of rehabilitation, and symptom irritability may influence shared decision making about the optimal dose of an exercise.

7.6.3 *Does the muscle contraction type matter?*

The early success and subsequent popularity of eccentric exercise for Achilles tendinopathy (314) inevitably led to its exploration for RCRSP (315). Mirroring the initial promising results for Achilles and patellar tendinopathy, eccentric exercise for RCRSP was associated with improvement in shoulder pain and function (162, 316). However, as more studies were performed, the results gradually tended towards eccentric exercise being no better than concentric (317) or isotonic (318) exercise. The most recent systematic review and meta-analysis exploring the effects of eccentric exercise for RCRSP formalises this regression towards equivalence (283).

Similar to the substantial interest in eccentric exercise based on preliminary results in the Achilles and patellar tendons, isometric exercise enjoyed a surge in popularity after the publication of a seminal paper by Rio et al. 2015 (319), showing the analgesic effect of an isometric contraction for patellar tendinopathy. When testing the effectiveness of isometric exercise for people with

RCRSP, the best available evidence suggests it's no better than simple ice therapy (320, 321). For tendinopathy in general, isometric exercise does not appear to be superior to isotonic exercise for immediate pain relief or clinical outcomes (322). For tendinopathy in general, isometric exercise does not appear to be superior to isotonic exercise for immediate pain relief or clinical outcomes.

7.6.4 Should exercise be supervised?

Current meta-analyses report no differences between supervised and unsupervised exercise for individuals with RCRSP (306, 323). A RCT published since, compared a supervised physiotherapist-led training regimen with an education and exercise leaflet, following a corticosteroid injection for both groups (324). At six months follow-up, the supervised physiotherapist-led exercise group demonstrated a significant improvement in shoulder pain and function. There was no difference at 6 week and 12-month follow-ups. A possible explanation for these results was the disproportionately higher exercise adherence in the supervised exercise group compared to the unsupervised group. Based on the available evidence, decision making on the level of supervision of an exercise program should be made with consideration of individual patient circumstances.

7.6.5 Should pain be permitted during exercise?

A systematic review and meta-analysis found that painful therapeutic exercise was not a barrier to experiencing a successful outcome with exercise therapy for a variety of musculoskeletal conditions (325). In fact, at short-term follow up, exercising into pain was significantly better (325). Within this meta-analysis, three of the included studies were classified as RCRSP (162, 316, 326). There were no significant differences in long term outcomes between exercise programs that permitted pain and those that prohibited pain. In the short-term, the Holmgren et al. 2012 trial demonstrated that painful exercises (up to 5/10 on a 0-10 scale) were associated with superior outcomes (316). This does not imply that permitting painful exercise causally explains the superior benefits observed at short-term follow-up, or any time frame, but it does demonstrate that exercising into pain need not be avoided or demonised as a rule. Individual circumstances will of course dictate the level of pain permitted, if any, and it is conjectured that exercising into pain when pain catastrophising is high could be counterproductive (311).

The common view that there is no best exercise approach (on average) for helping individuals with RCRSP is thus supported, and uncertainty envelops much of the implementation of exercise therapy.

7.7 WHAT CAN WE LEARN FROM THE LIVED EXPERIENCE OF INDIVIDUALS WHEN IT COMES TO EXERCISE FOR RCRSP?

It would be remiss to explore the role of exercise for managing RCRSP without considering the lived experience of individuals. Qualitative research reveals that participants randomised to an exercise-arm of a clinical trial can feel disappointed and sceptical, preferring a manual therapy-based approach (261). Conversely, other research highlights some individuals prefer exercise-based rehabilitation due to previous failure of traditional hands-on approaches (261, 327). This is concordant with recent research illustrating individuals often want and expect exercise from their physiotherapist, as described by a participant in the Subialka et al, 2022 qualitative assessment (328, 329).

“I’m just looking for them to teach me how to do the exercises I need to do at home to keep that range of motion going and to knock that pain level down without major surgery” (329).

A qualitative investigation exploring how and why individuals with lived experience of RCRSP believed exercise helped their symptoms reported all participants in the study had a positive experience with exercise, but only under certain conditions (327). Foremost among these conditions was the therapeutic relationship with their treating clinician, in which a failure to build a strong therapeutic relationship led to the inevitable failure of prescribed exercises. Another identified clinical condition, in this study and others (262), was the importance of an individualised exercise program, rather than a seemingly generic regimen.

“Yeah, it felt like it was a more tailored approach to me about me getting better as opposed to just a cookie cutter; here’s a default program for six to eight weeks that should make you better. Everyone does the same thing approach” (327).

Other commonly expressed barriers to engaging with an exercise program are poor access to equipment, uncertainty about approximate recovery timeframe, lack of motivation and time, and beliefs and expectations about whether exercise is the appropriate treatment for their shoulder pain (262, 330). Conversely, cogent advice and education about their shoulder condition and how to perform their exercise program, access to equipment, lack of exercise burden, and a supportive social network were key facilitators of engaging with an exercise program (262, 330).

The qualitative literature highlights the complexity and context-dependency of an individual’s experience engaging with an exercise program. However, when provided within the appropriate clinical context, exercise is often expected, wanted, and for the most part, positively received by

individuals with RCRSP.

7.8 HOW DOES EXERCISE HELP INDIVIDUALS WITH RCRSP?

The pursuit of effective treatments for RCRSP is of paramount research importance. Another important aim of clinical research, and science in general, is the generation of causal explanations of how a particular treatment caused a particular outcome. While hundreds of effectiveness trials exist testing exercise and other treatments for RCRSP, research focused on the specific identification of causal explanations (mechanisms) is sparse. A scoping review by Powell et al. 2022 identified 32 unique causal explanations that have been proposed for the beneficial effect of exercise for individuals with RCRSP, of which the vast majority pertained to traditional biomechanical mechanisms, such as muscle strength, motor control, and acromiohumeral distance (234). Very few of these biomechanical causal explanations have been tested, much less verified, by appropriate experimental methods and remain hypothetical (170, 234).

Mediation analysis is an empirical method of ascertaining how a treatment causes an outcome (127), for example, how does resistance exercise reduce shoulder pain? Mediation analyses investigating the causal mechanisms of exercise for shoulder pain are scarce and only two could be identified at the time of writing (246, 331), of which, both warrant discussion. Hotta et al. 2022 conducted a secondary mediation analysis of an RCT which compared general periscapular muscle strengthening exercises to general periscapular muscle strengthening plus scapular stabilisation exercises (246, 332). They reported that scapular motion, position, and muscle strength did not mediate shoulder pain and disability outcomes in people with RCRSP.

Gutierrez Espinoza et al. 2023 conducted an RCT comparing specific exercises to general exercises for people with RCRSP (331). For clarity, the specific exercises aimed to improve scapular orientation, both static and dynamic, and to optimise the position of the humeral head in the glenoid to prevent superior translation (presumably to avoid subacromial impingement). The general exercises were targeted towards improving the strength, mobility, and coordination of the shoulder girdle to ‘unload’ the subacromial space. The results of the trial showed a significant improvement in shoulder pain and disability in favour of the specific exercise group, but the difference was not clinically meaningful. Interestingly, the effect of the specific exercise program was reported to have been partly mediated through a reduction in kinesiophobia, possibly representing a treatment target for clinicians with patients who present with higher levels of kinesiophobia. It is unclear what aspect of the specific exercise program led to a reduction in kinesiophobia, or whether this could be achieved via other exercise approaches. For example,

qualitative research highlights that individuals express a reduction in kinesiophobia via simple strengthening-based exercise (327).

In the qualitative research literature, when individuals with lived experience of RCRSP were asked about how exercise helped their shoulder pain, the following three mechanisms were frequently reported: 1) improvements in muscle strength, 2) changes to psycho-emotional status, and 3) the acknowledgement of the widespread positive health effects of exercise (see Table 12 for supporting quotes) (327). Patient perceptions of exercise mechanisms approximate those proposed in the scientific literature in relation to shoulder strength but differ in the level of importance attached to psycho-emotional mechanisms (234).

At this stage, there is a void of knowledge regarding the causal mechanisms for improvement associated with exercise for RCRSP. However, current evidence indicates that traditional targets of exercise, including increasing muscle strength, optimising scapular position and motion, and increasing acromiohumeral distance may not explain clinical improvements in shoulder pain and function (170, 234). Psychological constructs, such as kinesiophobia and pain self-efficacy, are promising mediators and treatment targets, but more research is needed to corroborate this hypothesis. Another possible mechanism is restoring biochemical homeostasis to the shoulder tissues (221) but this too needs further research. At this juncture, we recommend clinicians refrain from providing definitive monocausal explanations for the effect of exercise (e.g. optimising scapular movement, improving strength) and rather advise that exercise may help reduce shoulder pain and improve shoulder function via a number of inter-related biopsychosocial mechanisms (170). Further research is crucial to understanding the causal pathways through which exercise confers a benefit to individuals with RCRSP, which may improve the implementation and clinical outcomes of exercise therapy.

Table 12: Causal mechanisms of exercise expressed by individuals with lived experience of rotator cuff-related shoulder pain

Causal mechanisms	Supporting quotes
Improvement in muscle strength	“And then the second I started strength training, I felt, yeah, just doing one exercise, every part of my shoulder was engaged. I was feeling that instant connection between the exercise I was doing and a positive improvement in my shoulder” (327).
Changes to psycho-emotional status	“Just restoring that faith in my shoulder, I suppose, which is what he got me to eventually do with all of the strength exercises” (327).

Exercise has widespread positive health effects	“It's a positive. It's beneficial. Feels good [exercise]... Obviously exercise is a good thing, if done right. It's good for joints. It's good for muscle. It's good for tendons. It's good for ligaments. It's good for strength. It's good for mental health” (327).
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7.9 NAVIGATING UNCERTAINTY: THEORETICAL CONSIDERATIONS FOR USING EXERCISE THERAPY

The current societal burden of musculoskeletal pain is profound and is only expected to increase (2, 333). This is predicted to increasingly strain already strained health care systems, and as such physiotherapists are encouraged to provide high-value care (334, 335). High value care is defined as delivering an intervention where the probability of benefit exceeds probable harm (336). For many non-traumatic musculoskeletal conditions, RCRSP included, the benefits of various surgical and non-surgical interventions are equivalent and modest, making it a clinical challenge to select an obvious high value treatment for an individual seeking care. Perhaps another way to approach the provision of high value care is *high quality care* (335) or the *right care*. In 2017 the Lancet published the *Right Care Series* and defined the *right care* as “care that is tailored for optimising health and wellbeing by delivering what is needed, wanted, clinically effective, affordable, equitable, and responsible in its use of resources” (336). Exercise for RCRSP is modestly effective (101, 103, 156), often wanted (11, 327), relatively affordable, and cost-effective (337). We submit that exercise is equitable and responsible in its use of resources, certainly when compared to surgery for the majority of cases (338). Exercise therapy can also be delivered in a timely fashion, without intensive supervision or extensive delay, and has been shown to be effective for patients on a waiting list for shoulder surgery (316). Whether it is needed in a particular clinical scenario should be a shared decision-making process between the individual seeking care and the treating clinician (308).

Shared decision making is a dynamic process in which the clinician and patient are empowered to make health care decisions collaboratively, with due consideration of the benefits and harms of available treatment options, and the individual patient preferences, values and circumstances (308, 339). Shared decision making is considered appropriate when there is not one clearly superior treatment approach available (339). This applies to both selection of a treatment, such as exercise, and also to the delivery of a chosen treatment, such as the exercise parameters. As emphasised in Section Three of this paper, uncertainty underpins much of the provision of

therapeutic exercise for an individual with RCRSP, and in such cases it is considered best practice to invoke shared decision making when choosing and implementing a treatment. What this looks like in clinical practice will be expounded upon in Section Seven. It must be emphasised that exercise is one, but not the only, option to help an individual diagnosed with RCRSP, however, because exercise therapy largely satisfies the *right care* criterion, we propose it is well placed to remain a principal treatment option for RCRSP.

7.10 NAVIGATING UNCERTAINTY: PRACTICAL CONSIDERATIONS FOR USING EXERCISE THERAPY

If the shared decision is to proceed with a trial of exercise therapy, in conjunction with appropriate advice and education (151), how might one construct an effective program given the enduring uncertainty surrounding much of its implementation? (Figure 15).

If an aim of exercise is to reduce shoulder pain, there are many approaches that may be considered. The uncertainty of how exercise causes a reduction in shoulder pain means the identification of traditional exercise targets, including weak and tight muscles, and aberrant scapular motion and position, need not dictate the selection of exercise type. With this in mind, the clinician is encouraged to select an exercise type and progression that they, and most importantly the patient, are most comfortable with, and has the least number of barriers (financial, exercise complexity, time constraints etc.) for adherence, and is tailored to their clinical presentation. If the clinician and patient agree to trial a form of resistance exercise, the type of contraction (isometric/isotonic/eccentric), the intensity of exercise, and the overall dose of the exercises will largely depend on what the patient can tolerate at the time and their goals for rehabilitation. There is inherent flexibility in this, will likely vary from patient to patient, and should be fit for purpose. Clinicians might consider conducting ‘exercise experiments’, similar to behavioural experiments as described in the Shape-Up-My-Shoulder rehabilitation program (90) and the cognitive functional therapy literature (340), where an exercise type, intensity, and context is trialled and adjusted based on the patients response. An approach similar to this has been described as being helpful by individuals with lived experience of RCRSP (327). This approach makes space for a plurality of exercise and movement types and parameters to be trialled depending on the individual’s symptom irritability, preferences, and feedback. The level of physiotherapist supervision will be an important conversation between the clinician and patient, and in the absence of robust evidence to sway clinical decision making one way or the other, this will depend on the specific clinical scenario. However, physiotherapists are encouraged to transparently communicate the equal effectiveness of supervised and unsupervised exercise for RCRSP and allow the patient to come to their own

decision. When it comes to pain during exercise, rather than dogmatically allowing or avoiding pain, the clinician is encouraged to gently explore the nature of any pain experience with a particular exercise or movement (Table 13), assuming a therapeutic alliance has first been established. The information derived from this exploration may be used to facilitate the collaborative construction of a tailored exercise program (327). This ‘Darwinian’ approach to exercise selection means that only the most appropriate exercises for an individual with RCRSP will survive and make it into a program.

Figure 15: The clinical uncertainty of delivering therapeutic exercise for rotator cuff-related shoulder pain



Table 13: Questions to help clinicians navigate shoulder pain during an exercise experiment

Example questions	Possible information gathered from questions
Question: Is the pain you’re experiencing during this exercise familiar, or does it feel different?	This could help decipher whether the pain is related to a ‘muscle burn’ or is provocative of their familiar (normal) pain. If the pain is more related to a ‘muscle burn’, the exercise need not be dramatically modified, provided the patient can tolerate the intensity.
Question: Does the pain settle when you stop the exercise? Follow-up Question: How long after?	This can help guide decision making about whether the patient can tolerate this exercise, done this way, at this time. Typically, it is advised that their familiar pain return to baseline levels within 30

	minutes of performing the exercise. Some delayed onset muscle soreness should be expected in the following days.
Question: What are your thoughts and feelings during this exercise?	This question may reveal whether there are unhelpful beliefs about movement and pain, which could lead to further discussion about whether these beliefs are impacting their recovery or how well they correspond to known evidence.
Question: Do you think your pain is changeable? What happens to your pain if we: • Change the load? • Change the ROM? • Change the lever (moment arm)? • Change the plane of movement? • Change the contraction type? • Try in a different position? (E.g. side lying Vs standing)	This part of the exercise experiment is important and may provide information about the movements and loads your patient can tolerate at this time. This information can subsequently guide creation of a tailored exercise program. Experiencing a reduction in pain by adjusting movement, load, or context could reinforce to the individual that their pain is modifiable, perhaps leading to renewed confidence of a positive outcome.
Question: How does your pain respond with more repetitions of exercise? Does it get better, worse, or stay the same?	Pain that gets better with more repetitions could indicate low symptom irritability and might greenlight a larger exercise dose. Pain that worsens with more repetitions might mean a lower dose exercise program is needed in the short term. Unchanging pain could be amenable to either, in a trial-and-error approach.
Question: Would you feel confident performing this exercise, with this level of shoulder pain, unsupervised at home? Follow-up question: Would you feel confident progressing/regressing the exercise based on the evolution of your symptoms?	These questions can give you an insight into the depth of understanding and self-efficacy an individual has about a particular exercise program. Ideally, the individual will feel empowered and confident to take control of their exercise program and recovery and be able to engage with the program unsupervised.

As the pain settles, the clinician and patient might start to think about using exercise to enhance the physical function and performance of the shoulder, perhaps to facilitate a return to work or a recreational pursuit that demands moderate use of the shoulder. In this clinical scenario, it is logical to start to think about exercise more from a classical biomechanical standpoint. Is there a certain level of shoulder strength required for their job, sport, or recreation? If yes, extra thought might be given to principles of strength and conditioning, such as exercise intensity, volume, and

frequency. Will the shoulder be required to tolerate repeated loads? If yes, perhaps more thought should be directed towards contraction type, including plyometric type exercise. What kinds of movements will be expected of the shoulder? Various combinations of pushing, pulling, lifting, raising, rotating, and carrying can be incorporated into an exercise program to best prepare the shoulder for return to work, sport, or recreation. Rehabilitation can also include the kinetic chain (341). A useful heuristic to help guide exercise-based rehabilitation for clinicians is that specificity of exercise type, intensity, volume, and contraction type seems to matter little for reducing the experience of shoulder pain but might matter more for enhancing shoulder function and performance.

7.11 CONCLUSION

Exercise therapy is a versatile and for many an effective treatment option to use in the management of RCRSP. Crucially, exercise appears to largely satisfy the right care criterion and can be delivered in a timely and unsupervised fashion, which may demarcate it from other common musculoskeletal treatments. However, as this critical review has highlighted, uncertainty underpins much of the delivery of therapeutic exercise, and it may not be suitable for everyone. There is uncertainty about the optimal anatomy of an exercise program, but this need not preclude action. The use of exercise experiments may help guide exercise selection in a way that naturally tailors an exercise program appropriate for an individual. We recommend the continued consideration of exercise therapy for appropriate individuals with RCRSP governed by a shared decision-making process and acknowledge the considerable research to be done to improve our understanding of the role exercise plays in helping individuals with RCRSP.

CHAPTER 8: Assessing the effectiveness of exercise therapy for rotator cuff-related shoulder pain from a novel perspective. What can we learn from applying Bradford Hill's viewpoints of causality?

8.1 PREFACE

This research program has identified substantial limitations of the evidence-base and significant knowledge gaps regarding how and why exercise is effective for RCRSP, which raises questions about the causal claim of exercise therapy. In establishing a causal claim, evidence of mechanisms and probabilistic evidence are considered, and in the case of exercise for RCRSP, there exists significant uncertainty regarding its causal mechanisms and absolute effectiveness when compared to a placebo or education control.

This chapter aimed to explore the question of effectiveness from a unique perspective, going beyond effect size alone. The Bradford Hill viewpoints, introduced in Chapter 1, are an established set of considerations used for establishing a causal claim or treatment effectiveness in epidemiology and the philosophy of medicine. In this chapter we apply the Hill viewpoints to the literature regarding exercise therapy for RCRSP to assess its causal claim.

The following manuscript is under peer review in *Shoulder and Elbow*. The following co-authors contributed to the manuscript: Dr Ben Schram, Dr Jeremy Lewis, and Dr Wayne Hing.

8.2 ABSTRACT

Background

Exercise therapy for rotator cuff related shoulder pain has faced increasing scrutiny due to limitations of the evidence-base and underwhelming clinical effects. These shortcomings confound firm conclusions about the causal role of exercise for reducing the pain associated with rotator cuff-related shoulder pain.

Methods

This review uses an alternative causal framework, the Bradford Hill viewpoints, to evaluate the causal claim of exercise therapy for rotator cuff-related shoulder pain. The Bradford Hill viewpoints facilitate a more comprehensive analysis of exercise therapy for rotator cuff-related shoulder pain that goes beyond, but still considers, statistical correlation (effect size).

Results and discussion

This review was unable to provide definitive evidence to corroborate or refute the causal claim of exercise therapy for rotator cuff-related shoulder pain. However, there are plausible explanations, other than causation, that may account for the modest association between exercise therapy and shoulder pain relief. Non-specific and contextual effects most likely explain a significant proportion of its total effect. Heterogeneous use of diagnostic labels and selection criteria in clinical research, poor reporting of exercise interventions, and a lack of rigorous mechanistic evidence, further undermines robust evaluation of the causal relationship between exercise therapy and shoulder pain relief.

8.3 INTRODUCTION

Exercise therapy is a widely recommended treatment for RCRSP (42) because it appears to out-perform no treatment and usual care comparators (101, 102), and can be delivered efficiently in a variety of ways and settings (342, 343). Importantly it is also a treatment valued by patients (327, 343). However, modest effect sizes, poor quality evidence, uncertainty of efficacy, and ambiguity pertaining to causal mechanisms, has led to exercise as a therapeutic intervention being subjected to increasing scrutiny (343).

In a research utopia, high quality appropriately powered, double blinded, allocation concealed, randomised controlled trials (RCTs), with no loss to follow up, comparing treatment A, to sham treatment B, to natural history (C) would be considered ideal to demonstrate the efficacy and effectiveness of the treatment of interest (A). In the domain of non-pharmacological and complex treatments, such as exercise therapy, research utopia might be an illusion, particularly as it relates to designing and implementing an appropriate placebo control group to assess treatment efficacy (133). Placebo controlled trials of exercise therapy for musculoskeletal conditions, including RCRSP, are rare and when they are conducted the placebo control group often differs considerably from the experimental exercise group, making it hard to infer causation (305, 344-346). As such, randomised placebo-controlled trials that compare apples with plastic oranges provide imperfect information regarding the efficacy of exercise therapy. Methodological limitations also extend to more pragmatic trial designs in which exercise is often compared to a no treatment or usual care control, primarily because there is an uneven allocation of contextual effects between the treatment and control group (139).

In 1965 Sir Austin Bradford Hill, a pioneering English epidemiologist and medical statistician who is often credited as conducting medical science's first randomised controlled trial, proposed nine viewpoints to consider when assessing the causal claim of an apparent association (Table 14) (132). They weren't intended to represent a rigid criterion to support or refute causation but act as considerations to inform appraisal of causal claims (133). Hill's viewpoints have become influential in epidemiology and the philosophy of medicine (133) and are viewed as particularly useful in cases where there is imperfect or inconclusive RCT evidence, especially in non-pharmacological treatments where designing a placebo-controlled trial is challenging (e.g. exercise therapy) or indeed unethical (e.g. smoking) (133, 347). The Hill viewpoints encourage consideration of broader evidence, such as mechanistic evidence, rather than clinical study evidence alone when evaluating causal claims (138). In fact, Hill's viewpoints are an intellectual seed of the modern-day evidence-based medicine (EBM) 2.0 movement, termed EBM+, where it's proposed

that evidence from mechanistic research and RCTs are of equal import for establishing a causal claim (133, 135).

Hill's viewpoints were originally formulated to help evaluate the causal claims of the onset of disease (e.g. the onset of lung cancer and its association with smoking), however there have been recent efforts to use Hill's viewpoints to assess the effectiveness of medical and physiotherapeutic treatments (133, 139). Henriksen et al 2024 (139) used Hill's viewpoints to evaluate the causal relationship between exercise therapy and pain relief in knee osteoarthritis and reported insufficient evidence to support or refute claims of causation. There have been no such efforts to use Hill's viewpoints to assess the causal claim of exercise therapy for RCRSP, and given the shortcomings of the evidence-base, a similar analysis may help sharpen our understanding of the relationship. An overarching aim of Hill's viewpoints is to make progress towards answering the question: is there any other explanation, equally or more likely, other than cause-effect, for the observed association? (132). With this in mind, the primary aim of this narrative review is to apply Hill's viewpoints to the relevant shoulder literature to better understand the sum of forces influencing or confounding the apparent association between exercise therapy and shoulder pain relief in individuals with RCRSP. Secondly, this review, combined with others (139), may serve as reference points for further evaluation of exercise therapy, and other common physiotherapeutic treatments, for suitable musculoskeletal conditions using Hill's viewpoints.

Table 14: Bradford Hill viewpoints with interpretation and explanation

Bradford Hill viewpoint	Explanation of viewpoint
10. Strength of association	Magnitude of effect. A strong association is more likely to be causal than a weak one (138).
11. Consistency	Multiple observations made by different observers with different instruments mean the association is more likely to be causal (138).
12. Specificity	If an outcome is best predicted by one primary factor, the causal claim is more credible (138). In rehabilitation parlance: is an improvement in shoulder pain associated with a specific mechanism of exercise or are there other reasonable explanations? (139)
13. Temporality	A cause must precede an effect (138).
14. Biological gradient	There should be a direct dose-response relationship between the independent variable (exercise) and the dependent one (pain outcome) (138). In rehabilitation parlance: a higher dose of exercise should induce greater pain relief.

15. Plausibility	An association is more likely to be causal if there is a rational and theoretical basis for it. Mechanistic evidence is required (138).
16. Coherence	An association is more likely to be causal if it coheres with other knowledge about the natural history and biology of the condition under study (138). This can be useful for ruling out alternative explanations for a treatment's effects (133).
17. Experiment	Any related research that is based on experiments will make a causal inference more plausible (138).
18. Analogy	The likelihood of a causal relationship may be strengthened if a comparable association is observed between the same outcome and an analogous exposure or the same exposure and an analogous outcome (140). In rehabilitation parlance: if there is evidence from other musculoskeletal conditions of an association between exercise therapy and shoulder pain reduction, this may support causation and lower the burden of proof.

*Legend: Adapted from Greenhalgh et al. (138) under [CC-BY-NC-4.0](#). Citation: Greenhalgh T, Flisman, D., Cane, D.J., Oliver, M., Macintyre, C.R. Adapt or die: how the pandemic made the shift from EBM to EBM+ more urgent. *BMJ Evid Based Med*. 2022;27:253-60. DOI: <https://doi.org/10.1136/bmjebm-2022-111952>.*

8.4 STRENGTH OF ASSOCIATION

One of the earliest systematic reviews investigating the effect of exercise for RCRSP was a Cochrane review published in 2003 and reported weak evidence that an exercise program conferred a clinical benefit at short- and long-term follow up compared to a placebo comparator (de-tuned laser) for rotator cuff disease (348). This conclusion was based on the results of only one trial (349). Many more systematic reviews were published in the ensuing decade, most of which reported generally positive findings for exercise therapy, with some exceptions (350, 351), albeit often based on limited or weak evidence (352-356).

The earliest systematic review with meta-analysis was by Hanratty et al. 2012 (357) who reported a combined effect size of SMD = 0.13 (trivial effect) (4 studies, n=369) for therapeutic exercise in reducing short term pain associated with RCRSP. This effect estimate was based on 'strong' evidence using the best-evidence synthesis criteria. A Cochrane review published in 2016 found high quality evidence, based on only one trial (104), that exercise and manual therapy did not confer a clinically meaningful benefit compared to a placebo control (178). A systematic review and meta-analysis by Steuri et al. 2017 (101) reported there was very low-quality evidence that exercise therapy conferred a benefit over no treatment with an effect size of SMD = 0.94 (5 studies, n=189). This was deemed a large effect but due to the very low certainty of evidence, caution is

advised when interpreting these results, as the true effect is likely to be substantially different from the effect estimate (358).

More recently, two systematic reviews with meta-analysis have been published exploring the effect of exercise on shoulder pain relief for RCRSP. Naunton et al. 2020 reported that progressive or resisted exercise versus no treatment or placebo confers a 10.7-point reduction in overall pain (0-100 scale) (4 studies, n=271) (156). This decrease was statistically significant but of uncertain clinical benefit. The result was slightly better for pain with activity (24.7-point reduction on a 0-100 scale) but again was assessed to be of uncertain clinical importance. The quality of evidence was judged to be low. Non-progressive or non-externally resisted exercise, conversely, did not provide any benefit when compared to no treatment or placebo controls. Liaghat et al. 2022 reported that supervised exercise training provided a reduction of 1.68 points (0-10 scale) (4 studies, n=286) for pain at rest, and 1.84 points (0-10 scale) (5 studies, n= 353) for pain during movement, compared to a no exercise control (306). In contrast to the Naunton et al. 2020 findings, this was a statistically and clinically meaningful difference. The pain at rest effect was weakened to 0.96 points after sensitivity analysis, thus challenging the clinical significance of supervised training compared to no training. Reflecting previous reviews, the quality of evidence was assessed to be low and thus only weak recommendations for exercise training could be made (306). When progressive resistance exercise and motor control exercise are compared to a primarily education-based control group, exercise has hitherto failed to confer a superior therapeutic benefit according to two high quality RCTs (61, 151).

Taken together, there appears to be a modest association between exercise therapy and pain relief for individuals with RCRSP when compared to no treatment or no training controls based on current systematic reviews and meta-analyses. The results of one high quality trial (104), which provides the basis for the recommendations of the most recent Cochrane review, reports no clinically meaningful difference between a combination of exercise and manual therapy versus a placebo control. Furthermore, evidence from two high quality RCTs demonstrate the provision of a structured and supervised exercise program does not lead to better pain relief compared to an education-based control. Before dismissing the causal relationship between exercise and pain relief for RCRSP in the first instance, it is prudent to remember Hill made clear a weak association is not necessarily a death knell:

“We must not be too ready to dismiss a cause-and-effect hypothesis merely on the grounds that the observed association appears to be slight” (132).

8.5 CONSISTENCY

Therapeutic exercise has been investigated by various research groups from around the world, however the characteristics of the exercise program under investigation often differs between studies (234). Exercise interventions used in clinical research vary widely across multiple domains, including exercise type, duration, dose, level of pain permitted, causal explanation and clinical rationale, education delivered, outcome measures used, and whether exercise is delivered alone or in combination with other therapies (234, 304, 359). Complicating replication, and indeed interpretation, of many clinical studies exploring exercise for RCRSP is the consistently poor reporting of the exercise intervention used according to the CERT and TIDieR checklists (107, 304, 359). This is illustrated by the finding that only two RCTs, out of a sample of 104, satisfied each criteria of the TIDieR checklist (61, 179), and only one fulfilled all criteria of the CERT checklist (61) according to a recent systematic review (359). The poor reporting of exercise intervention characteristics involved core components of an exercise program, such as the exercise dose, adverse events, whether the exercise was individualised or generic, information regarding progression and regression of exercises, whether the exercises were executed as planned (fidelity), and adherence to the exercise program (359, 360). The overall poor reporting of exercise interventions represents a serious and fundamental limitation of the evidence-base of exercise for RCRSP, confounding interpretation and translation of research into practice, and hampering replication of an exercise intervention in future research.

Consistency of evidence is also a key component of the GRADE system to classify quality of evidence (361) and there are some overlaps between the GRADE classification system and Hill's viewpoints (358). Under the GRADE framework for assessing the quality of evidence, a high level of inconsistency, often measured by the I^2 statistic, may result in the downgrading of evidence and reduced confidence in the effect estimate (358, 361, 362). When examining the consistency of effect estimates of exercise therapy for RCRSP using the I^2 measure, there exists high statistical heterogeneity (inconsistency) that ranges from 80-88% (101, 306, 357). One meta-analysis, Naunton et al. 2020, is notable because of its low heterogeneity when comparing progressive or resisted exercise to no treatment or placebo (156), meaning its overall effect of 10.7 points (out of 100) for pain reduction in favour of exercise could be viewed as a consistent effect estimate.

Another way to evaluate a possible causal relationship between exercise and pain relief for individuals with RCRSP is to explore its stability or sensitivity across variable background conditions (363). Put simply; does the effect hold in different contexts? Reviewing qualitative research is one way to explore this question and a recent study reported the success of an exercise

program for an individual with RCRSP is contingent upon contextual factors, most prominently the strength of the therapeutic relationship and the perceived individualisation of the exercise program (327). Thus, the effect of an exercise program may be context dependent and subject to variation across different background conditions.

There is also inconsistency in the evidence-base regarding the diagnostic label used to describe the clinical presentation we term RCRSP (20, 234). Reflecting the inconsistency of the diagnostic label, the diagnostic criteria used to recruit participants to a study also varies extensively (20). Moreover, there is a lack of consensus on whether to include potential participants into a study with a full thickness rotator cuff tear, with some studies including and others excluding, for arbitrary reasons (20). The lack of consensus regarding the diagnostic label and criteria represents another concern that may confound attempts to compare different studies.

Taken together, many studies over many decades conducted in various settings have investigated exercise, aggregating to produce a consistently modest overall effect of therapeutic exercise in decreasing shoulder pain. However, within this modest effect there is frequently high statistical heterogeneity indicating inconsistent and possibly untrustworthy effect estimates. Poor reporting of exercise interventions, lack of replication of exercise programs across different studies, probable context-dependency, and variation of diagnostic label and criteria used, confounds interpretation of the available evidence, precluding conclusions that exercise therapy consistently and predictably causes a reduction in pain in individuals with RCRSP.

8.6 SPECIFICITY

Exercise therapy is considered a complex treatment, producing an effect on pain via numerous interacting mechanisms (149). Theoretically, the total effect of an intervention (e.g. exercise therapy) can be partitioned into three components: specific, non-specific, and contextual effects (364, 365). Specific effects are the intended target of the intervention under investigation (e.g. resistance exercise), and in the shoulder literature most often take the form of neuromuscular constructs, such as increasing shoulder strength or optimising scapulothoracic kinematics (234). Non-specific effects refer to changes which can occur without treatment, such as natural history and regression to the mean (365, 366). Contextual effects emerge at the patient-clinician interface, extending from the primary therapeutic relationship to the health care setting within which the interaction takes place (367), driving both positive and negative outcomes (344). Accumulating research indicates a considerable proportion of the total effect of non-pharmacological treatments for musculoskeletal (MSK) pain, including exercise and manual therapy, is explained by non-

specific and contextual effects (344, 366, 368). A meta-analysis using the proportion attributable to contextual effects (PCE) metric reported that 46% of the total effect of exercise therapy for musculoskeletal conditions is attributable to contextual effects (344). However, placebo-controlled exercise trials for MSK pain are rare (346, 364, 366) particularly 3-arm trials (treatment group, placebo group, and no treatment group), which are considered the gold standard for disentangling contextual effects (364-366), calling into question the validity of this PCE estimate (365, 369). Nonetheless, the overall effect of exercise therapy for RCRSP is almost certainly laden with specific, non-specific effects, and contextual effects, the exact proportion of which is currently uncertain. Thus, current evidence suggests the association between exercise therapy and shoulder pain reduction is not fully explained by specific mechanisms often targeted with exercise.

The lack of specificity underlying the association between exercise and pain is underscored by the equivalent outcomes of divergent exercise approaches (105). The current consensus is there is no best exercise approach for reducing the pain associated with RCRSP, rather exercise prescription should be individualised and based upon a shared decision making process (343). That disparate exercise programs can be associated with similar reductions in pain (151) challenges the prevailing biomechanical rationale underpinning exercise therapy, because different exercise types often have specific and unique treatment targets and philosophies (343). For example: resistance exercise is primarily hypothesised to work via changes in shoulder strength, and motor control exercise is believed to work via optimising movement of the shoulder girdle, however at this stage there is no empirical support for these mechanistic hypotheses (170, 246).

Exercise does not specifically influence pain; it also has an impact on many other health variables. Higher load resistance exercise increases strength (370), higher volume resistance exercise increases muscle hypertrophy (370), stretching exercise increases flexibility (371), and exercise can also enhance pain self-efficacy (372) and reduce kinesiophobia (331). Moreover, exercise therapy is a versatile intervention that is recommended for conditions beyond the MSK system, including metabolic, psychological, neurological, cardiovascular, and pulmonary disorders (295).

There appears to be a non-specific and imprecise relationship between exercise and pain relief. However, Hill states; “*if specificity exists we may be able to draw (causal) conclusions without hesitation; if it is not apparent, we are not thereby necessarily left sitting irresolutely on the fence*” (132).

8.7 TEMPORALITY

All randomised controlled trials satisfy this viewpoint. Thus, there is substantial evidence of a temporal relationship between exercise therapy and pain reduction.

8.8 BIOLOGICAL GRADIENT

What is meant by exercise dose in the field of physiotherapy is obscure, but is commonly used in the resistance exercise literature to describe the load lifted, the number of repetitions, and the numbers of sets of repetitions (also referred to as volume) (310).

To investigate this viewpoint, it is necessary to evaluate varying-dose RCTs (138). The highest quality trial to date is the SExSI trial by Clausen et al. 2021 (179), who reported no added benefit of adding a large exercise dose to usual care compared to usual care alone. Similarly, other RCTs report no difference between a higher intensity resistance training program and a lower intensity regimen (166, 312). A review by Malliaras et al. 2020, which pre-dates the aforementioned RCTs, systematically explored the comparative effectiveness of higher dose and lower dose exercise for RCRSP (106). They reported, based on low to very low certainty evidence, conflicting evidence about the benefit of higher dose exercise for RCRSP (106). Specifically, based on one RCT, there was no clinically important difference in pain outcomes when comparing higher load and higher volume exercise with lower load and lower volume exercise (106). One might conjecture whether the demand for a biological gradient between exercise dose and pain relief is logical, as it is currently understood the optimal exercise dose is unique to an individual and is subject to change depending on symptom irritability (343). Certainly, it wouldn't make sense to ask "*is more surgery better for shoulder pain*"? (133).

Does the cessation of exercise lead to worsening shoulder pain? Exercise programs in clinical research vary in duration, ranging from approximately 4-16 weeks, however participant follow-up can extend beyond this timeframe. We evaluated studies that followed up participants for at least 3 months after the cessation of their formal exercise intervention. After narratively reviewing a sample of higher quality trials that satisfied this criterion, the cessation of exercise was not associated with a negative influence on pain trajectory (61, 186, 373, 374). In many cases pain continued to steadily improve long after the exercise program formally ended (186, 373, 374). What it is that exercise is influencing in the short term (if anything) that leads to longer term clinical improvements even after the cessation of the formal exercise program is uncertain and will be explored further in the following section.

In summary, there does not appear to be a dose-response relationship between the exercise dose and magnitude of pain relief. There also does not appear to be a relationship between the cessation of an exercise program and worsening of shoulder pain.

8.9 PLAUSIBILITY

In the philosophy of causality it has been proposed that evidence of correlation (in the form of clinical studies) and evidence of mechanisms are both equally important for establishing a causal claim (113). The plausibility viewpoint of Hill discussed here is concerned with mechanisms. Crudely, mechanisms explain how things work (113), and we're interested in the question; "*how does exercise work for individuals with RCRSP?*".

Pain is a subjective experience, making it a challenge (arguably impossible) for the physical therapist (PT) to treat directly. Thus, PTs are compelled to target intermediary variables (mediators) that are believed to lie on the causal pathway between the exercise intervention and the outcome of shoulder pain (123). For RCRSP, these intermediary variables almost always take the form of biomechanical constructs (rightly or wrongly), such as shoulder strength, acromiohumeral distance and scapulothoracic mechanics (234). To test the causal relationship between exercise (exposure) and pain (outcome), mediation analysis can be used to decompose the total effect into indirect and direct effects, where the indirect effect represents the portion of the treatment effect that travels through the selected intermediary variable (e.g. shoulder strength) (123). Mediation analysis has been proposed as a 21st century methodological upgrade for exploring the biological plausibility viewpoint (375).

Mediation analyses of exercise therapy for RCRSP are uncommon (343). At this juncture, there is evidence that reducing kinesiophobia partially explains the effect of exercise in a sample of individuals with RCRSP (331), but there is no direct evidence that traditional targets of exercise, such as increasing shoulder strength or optimising scapular mechanics explains the effect of an exercise program in reducing shoulder pain (170, 246). It is prudent to consider that if exercise therapy works partly through altering a psychological construct (s), there are most likely other non-exercise interventions (such as education) that may work through similar pathways to produce a similar treatment effect.

Other mechanistic studies exist in the form of in vitro analyses of rotator cuff tissue, which show a significantly different biochemical milieu between symptomatic and asymptomatic individuals (376). However, at this stage there is little direct evidence that a course of exercise therapy will induce meaningful positive biochemical change in the rotator cuff and related

structures, and that this change causally produces a reduction in shoulder pain. It is conjectured that exercise therapy may plausibly reduce shoulder pain through variations and gradations of changing tendon structure, altering neuromuscular performance, enhancing psychological constructs, and positively influencing local and systemic neuro-endocrine-immune function (234, 377), but this needs further research.

There are numerous biologically plausible mechanisms that may explain the beneficial effect of exercise therapy for RCRSP, however, investigation of these possible mechanisms of exercise using appropriate statistical techniques such as mediation analysis is in its infancy, and this knowledge gap should represent a priority item for researchers. Understanding the mechanisms of exercise could assist in the formulation of a clear and coherent description of therapeutic exercise, which may be important for consistency in future clinical trials. Bradford Hill articulated that “*what is biologically plausible is dependent on the biological knowledge of the day*” (132), and thus claims of plausibility are limited by background knowledge, which is liable to change over time, particularly in fields of research that are relatively new.

8.10 COHERENCE

The coherence viewpoint has been criticised for being similar to the plausibility and specificity viewpoints in their common pursuit of explaining possible cause-effect relationships between an exposure (exercise therapy for RCRSP) and outcome (shoulder pain) (140, 375), and has already been examined in its corresponding section. Furthermore, there is a rich history of medical treatments that appear to cohere with current science that turn out to be harmful, and conversely, treatments that contradict current knowledge that turn out to be beneficial (117, 120). As a result, the value of Hill’s coherence viewpoint when applied to medical and physiotherapeutic treatments is unclear. In this section, to avoid repetition, we will limit our discussion to the relationship between exercise therapy and pain reduction compared to current knowledge about the natural history of RCRSP, which was in fact explicated by Hill some 15 years before his seminal 1965 treatise (378). Understanding the natural course of a disease or musculoskeletal condition can help evaluation of possible treatment effectiveness.

The natural history of RCRSP is challenging to examine as a large proportion of individuals who experience an episode of shoulder pain will not consult a health care professional, much less be enrolled in a study (177). Limited evidence is available that maps the clinical course of RCRSP when left untreated, however one review suggests there is negligible change in shoulder pain or function when followed up at 3 and/or 6 months in a cohort of individuals with persistent RCRSP

(379). Another recent review, based on one study, reported that shoulder pain and function improved over 12 months in individuals with RCRSP in a ‘wait-and-see’ group, however this improvement fell well below the level judged to be fully recovered (380). With active treatment, it is reported there is a gradual improvement in shoulder pain over the first 12 months when receiving either usual care, surgery, or non-surgical intervention (including exercise therapy) (101, 156, 379, 381), thereafter improvement tapers off. Because of limited evidence about the natural history of untreated RCRSP, it is challenging to estimate what proportion of the total effect of exercise therapy might be due to specific mechanisms associated with exercise therapy and what is due to non-specific mechanisms (including natural history). However, as discussed in the specificity viewpoint and illustrated in Figure 16, there is reason to postulate a non-trivial proportion of common physiotherapy treatment effects may be attributable to variables such as natural history and regression to the mean.

Based on the evidence, it is not possible to determine whether the relationship between exercise and pain relief in individuals with RCRSP coheres with existing knowledge about the natural history of RCRSP. More research exploring the natural history of RCRSP is required and, indeed, encouraged.

8.11 EXPERIMENT

Experimental evidence exists in the form of RCTs, however as discussed earlier, these are imperfect (139).

8.12 ANALOGY

Exercise is a recommended treatment for many musculoskeletal conditions, including osteoarthritis, back pain, and various tendinopathies. However, the evidence-base for these conditions is confounded by similar problems to those outlined in this review, which renders attempts at establishing causation by analogy spurious. For example, exercise for knee and hip osteoarthritis are more comprehensively researched clinical conditions (382), able to draw from a far more extensive evidence-base, and yet claims of causation are similarly challenging to make (139). Across a range of musculoskeletal conditions from fibromyalgia to low back pain, evidence does not support the superior effect of exercise training compared to a placebo control (sham electrotherapy or placebo oral supplementation) (346). Evidential deficiencies also afflict other musculoskeletal conditions regarding superficial knowledge of the mechanisms of exercise (plausibility) (123, 383), absence of a dose response relationship (384, 385), context dependency of exercise (386), and the imprecise relationship between exercise and pain relief (366).

Table 15: Summary of Bradford Hill viewpoints applied to exercise therapy for rotator cuff-related shoulder pain

Bradford Hill Viewpoint	Applied to exercise therapy for RCRSP	Verdict
Strength of association	Modest effect in favour of exercise therapy when compared to no treatment control.	
Consistency	There is an inconsistent relationship between exercise therapy and pain relief.	
Specificity	There is a non-specific and imprecise relationship between exercise therapy and pain relief.	
Temporality	There is evidence from randomised controlled trials of a temporal relationship between exercise therapy and pain relief.	
Biological gradient	There is currently no dose response relationship between exercise therapy and pain relief. It must be questioned whether this a logical demand for exercise therapy.	
Plausibility	Exercise therapy may work via numerous plausible mechanisms, however further research is required to elucidate these mechanisms.	
Coherence	There is insufficient evidence to support or refute the claim whether the association between exercise therapy and shoulder pain relief coheres with knowledge about the natural history of RCRSP.	
Experiment	Experimental evidence exists in the form of RCTs; however, these are imperfect.	
Analogy	There is evidence from other musculoskeletal conditions that exercise therapy is associated with pain relief, however similar issues to those outlined in this review confound this analogy.	

8.13 CONCLUSION

“None of my nine viewpoints can bring indisputable evidence for or against the cause-and-effect hypothesis and none can be required as a ‘sine qua non’ (essential). What they can do...is to help us make to make up our minds on the fundamental question – is there any other way of explaining the set of facts before us other than cause and effect?”. Austin Bradford Hill (132).

The aim of this review was to narratively explore whether the modest association between exercise therapy and pain relief in individuals with RCRSP could be explained by anything other than direct cause-effect (Table 15). How, and to what extent, exercise therapy specifically reduces shoulder pain remains unclear, but it almost certainly involves non-specific and contextual mechanisms. The exercise programs, diagnostic label, and selection criteria often used in clinical trials is inconsistent, there is a non-specific relationship between exercise and shoulder pain relief, and the success of an exercise program is most likely context dependent. A dose response relationship is absent, evidence of mechanisms is sparse (subject to change with advancing knowledge), and causality by comparing to other MSK conditions is confounded by the same limitations outlined in this review. This review does not refute the causal claim of exercise therapy for RCRSP, rather it highlights the complex properties of exercise as a treatment for RCRSP, the limitations of published research investigating exercise for RCRSP, most notably the poor reporting of exercise program parameters according to TIDieR and CERT and outlines the need for more research to explore the mechanisms underpinning the effect of exercise. An effort to conduct more mechanistic research may complement evidence from clinical studies by identifying a valid causal pathway between exercise and shoulder pain relief, which may facilitate the construction of an unambiguous description of exercise to be used in clinical research and practice.

CHAPTER 9: Discussion, implications for clinical practice and directions for future research.

“No work can ever be finished. While working on it we learn just enough to find it immature the moment we turn away from it”. Karl Popper

9.1 PREFACE

This research program has comprehensively explored the causal mechanisms which may underpin the effectiveness of exercise therapy for RCRSP. The philosophical foundation of this thesis, critical realism, also facilitated exploration of the clinical context which may or may not support the activation of the causal mechanisms of exercise therapy.

This final chapter summarises this research program's main findings, strengths, limitations, and clinical implications. The main findings of this body of work are then discussed in context with the wider evidence-base, highlighting ongoing knowledge gaps regarding the causal mechanisms of exercise therapy for RCRSP, and concluding by offering recommendations for future research.

9.2 SUMMARY

The aim of this research program was to elucidate and synthesise the proposed mechanisms of benefit of exercise for the management of RCRSP. Given the scarcity of research exploring the causal mechanisms of exercise therapy for RCRSP, much of the research in this thesis took the form of mapping, surveying and exploring the prevailing hypotheses and beliefs proffered in clinical research and expressed by clinicians and individuals with lived experience of RCRSP. The studies within this thesis are an attempt to make progress towards answering the following questions:

1. What are the causal mechanisms proposed in clinical research to explain the beneficial effects of exercise therapy for individuals with RCRSP?
2. How and why do registered physiotherapists believe exercise therapy helps their patients with RCRSP?
3. What explanations do individuals with lived experience of RCRSP provide for a clinical improvement through engaging with an exercise program?
4. Are there any clinical conditions or contexts that facilitate or inhibit a positive experience with exercise therapy according to individuals with RCRSP?
5. How should clinicians use knowledge of causal mechanisms and their associated context in their practice?
6. Is it the specific targets of exercise therapy that helps people recover from RCRSP, or are there other explanations?

A scoping review was conducted to identify and synthesise the causal mechanisms proposed in clinical research. As far as we are aware, this was the first study to explore and publish the prevailing hypotheses of clinical researchers about how and why an exercise program may help participants in their study with RCRSP. This scoping review gathered baseline knowledge from 110 clinical trials about the hypothesised causal mechanisms underpinning the effect of exercise therapy and served as a reference point for subsequent studies exploring the views of clinicians and patients. This study has been cited on 20 occasions since its publication in 2022.

A cross-sectional international survey of registered physiotherapists was conducted to gain knowledge about the beliefs of physiotherapists regarding the mechanisms of exercise for RCRSP. The survey was able to reach 49 unique countries, spanning all but one continent (Antarctica). The results revealed surprising differences between clinicians and clinical researchers, with clinicians embracing psychosocial mechanisms of exercise more often. Moreover, knowledge was gleaned about the preferred diagnostic label for RCRSP, favoured exercise type and whether clinicians

believed more knowledge of exercise mechanisms would benefit their clinical practice. This study has been cited on 7 occasions since its publication in 2022.

A qualitative study, using semi-structured interviews, was conducted to explore the beliefs of individuals with lived experience of RCRSP about how and why exercise helped their shoulder pain. This qualitative investigation generated rich insights from the participants involved in the study, and the results were similar to those obtained from surveying registered physiotherapists. This qualitative study was also used to explore the treatment-mechanism-context-outcome relationship using a critical realist philosophy. To the best of our knowledge, this had not been done before in the RCRSP literature. By exploring the clinical context that promoted or inhibited identified causal mechanisms encourages clinicians to reflect about how their clinical practice may influence the outcomes of their patients. This study has been cited on 5 occasions since its publication in 2023.

A critical review of exercise therapy for RCRSP was conducted to integrate knowledge of causal mechanisms, with knowledge of effectiveness, the optimal exercise type and dose, and with the lived experience of individuals with RCRSP. This review pulled together distinct and contentious topics within the field of exercise for RCRSP and concluded by offering theoretical and practical considerations for clinicians when delivering exercise therapy to their patients.

A narrative review was conducted using the Bradford Hill viewpoints of causality to evaluate the causal claim of exercise therapy for RCRSP. Essentially, this narrative review seeks to answer the question; “is there any other explanation, apart from causation, for the apparent association between exercise therapy and reduced shoulder pain in individuals with RCRSP?”. Exploring this question facilitates an honest and rigorous evaluation of the causal claim of exercise therapy for RCRSP, perhaps providing a foundation for future research efforts.

The following section discusses the main findings, strengths and limitations, clinical implications, and recommendations for future research that may build on this research program.

9.3 DISCUSSION OF MAIN FINDINGS

This research program aimed to identify and synthesise the causal mechanisms hypothesised to underpin the beneficial effect of exercise therapy for individuals with RCRSP. Additionally, this thesis intended to explore whether clinical contextual features influenced the activation or inhibition of identified causal mechanisms, and to integrate the knowledge generated from this body of work with the wider evidence-base to make it accessible for clinicians. Overall, the identified causal mechanisms were manifold and varied depending on the particular stakeholder who was being

investigated. This was an unsurprising finding given the relative immaturity of the evidence base regarding the causal mechanisms of exercise therapy for RCRSP.

The first publication of this thesis was an editorial (Chapter 3) that formed via background reading of the literature at the front end of this research program. This editorial, published in the *Journal of Orthopaedic and Sports Physical Therapy*, served as an overarching research guide to think critically about exercise therapy for RCRSP, to ask deeper causal questions of how and why exercise may help individuals with RCRSP, and to reflect on its overall causal role in helping individuals in their rehabilitation journey. This study introduces the paucity of evidence supporting the assertion that resistance exercise helps individuals with RCRSP recover via an improvement in shoulder strength. This is an example of mechanistic reasoning, outlined in Chapter 1, where the mechanism of strength is psychologically compelling but ultimately lacking in empirical support.

The scoping review of this thesis, contained within Chapter 4, aimed to broadly map the common causal explanations proffered in clinical trials for the beneficial effect of exercise therapy for RCRSP. This review was inspired by other reviews in the chronic low back pain and knee osteoarthritis literature (181) and served as an appropriate starting point of this research program because causal mechanism research using robust statistical methods was lacking. The review identified 32 raw mechanisms that had been proposed in clinical research, and these were able to be organised into 4 themes: 1) neuromuscular, 2) tissue factors, 3) neuro-endocrine-immune, and 4) psychological. Neuromuscular mechanisms accounted for the vast majority of causal explanations (77%), of which shoulder motor control and muscle strength were the most common neuromuscular mechanisms. A somewhat surprising finding was the lack of acknowledgement of potential psychosocial mechanisms of exercise therapy, making up only 5% of all proffered explanations. This contrasts with findings from the chronic low back pain literature where psychosocial mechanisms are more often invoked and adds credence to the view that the shoulder lags behind the lumbar spine in terms of embracing the biopsychosocial model. Results from this scoping review corroborate the argument posited in Chapter 3, that there is a commonly held view that ‘getting stronger’ or ‘fixing movement patterns’ is what explains improvement with exercise therapy. Unfortunately, this view lacks empirical support and thus is a view that should be questioned. Other mechanisms that were mostly overlooked in clinical research, such as tissue biochemistry, also warrant further investigation given their biological plausibility and presence of supporting mechanistic evidence. In sum, causal explanations for the beneficial effect of exercise therapy for RCRSP are dominated by biomedical, specifically neuromuscular, mechanisms despite a lack of supporting evidence.

The cross-sectional survey of this thesis, contained in Chapter 5, aimed to identify the prevailing view of registered physiotherapists about how and why they believe exercise therapy helps their patients with RCRSP. The survey was able to recruit 480 physiotherapists from 49 countries, and, somewhat surprisingly, physiotherapists were more acknowledging of potential psychosocial mechanisms compared to clinical researchers. Psychosocial mechanisms and neuromuscular mechanisms were selected at roughly the same rate by physiotherapists, whereas clinical researchers proposed neuromuscular mechanisms at orders of magnitude higher than psychosocial mechanisms. Nonetheless, muscle strength was still the dominant neuromuscular mechanism believed to explain the effectiveness of exercise therapy, and resistance exercise was the most selected exercise intervention they would use. Critically, 90% of clinicians reported that more knowledge about the mechanisms of exercise therapy for RCRSP would benefit their clinical practice, supporting the aims of this research program. An interesting peripheral point is that clinicians were more likely to use the diagnostic label RCRSP, whereas the most used term in clinical research was shoulder impingement. Clinicians were therefore less likely to suggest enlarging of the subacromial space distance as a mechanism for a clinical improvement with exercise therapy. Perhaps this provides some preliminary support for the influence of the language used to label musculoskeletal conditions.

The qualitative study of this thesis, housed in Chapter 6, explored the views of individuals with lived experience of RCRSP who had engaged with an exercise program through their rehabilitation journey. This study was conducted within a critical realist philosophy of science, where causal mechanisms and contextual features were sought to explain the participants experience. The participants believed an improvement in shoulder muscle strength, changes to various psychosocial constructs, and a general improvement in health and wellbeing through exercise are what explained their positive experience with and clinical improvements through exercise. Again, the muscle strength mechanism was dominant, as it was in the scoping review of clinical trials and the survey of physiotherapists. Participants also provided rich insights regarding their psychological experiences with exercise therapy, which were mostly neglected in the empirical evidence-base. Participants also commonly mentioned that exercise is simply a good thing to do, like eating a healthy meal, which is going to improve their general health, which may in turn improve their shoulder pain. The individuals with lived experience of RCRSP had a well-rounded view of the potential mechanisms of exercise therapy for helping their shoulder pain. A novel aspect of this study, guided by the critical realist philosophy, was the identification of various contextual features that influenced the success of an exercise program. Participants frequently mentioned that a

strong therapeutic relationship was a necessary pre-condition to experience a clinical improvement with an exercise program. Furthermore, participants wanted to see that their exercise plan was tailored to their unique clinical presentation and goals, rather than being prescribed a generic program. If a perceived ‘cookie-cutter’ program was provided by the clinician, this often led to a poor outcome. Thus, not any exercise program will do, in the eyes of a patient, and the unique goals and characteristics of an individual should be front of mind of the clinician. Lastly, and perhaps obviously, participants wanted their exercise program to be effective, quickly. If it didn’t have an effect in a certain time period, this affected their adherence to and benefit from the exercise program. The development of a treatment-mechanism-context-mechanism-outcome model in this qualitative study is unique and has not been presented before in the shoulder literature. The implications of this study are that context matters, maybe even more than the actual dosing parameters of the exercise program itself. This is consistent with other process evaluations using a critical realist philosophy, where it is naïve to think that context won’t impact outcomes, and that you can simply package specific interventions and provide them to individuals and expect it will deliver a consistent and predictable outcome (142, 386).

The critical review, presented in Chapter 7, aimed to critically examine exercise therapy for managing RCRSP, considering both quantitative and qualitative evidence. The review highlighted several limitations of the literature, most notably the very low to low certainty of evidence supporting the effectiveness of exercise therapy, lack of efficacy when compared to a credible sham, and as discussed during this thesis, a lack of evidence pertaining to the causal mechanisms of exercise therapy. Moreover, the optimal exercise type, dosing parameters and supervision level of an exercise program are uncertain. Therefore, we were compelled to propose a solution to the question: “How might clinicians cope with the clinical uncertainty of prescribing exercise for RCRSP?”. We contend clinicians can navigate the uncertainty of whether to prescribe exercise or not because it largely satisfies the *right care* criterion, which may demarcate it from other interventions. Furthermore, clinicians can help overcome uncertainty by leaning into a shared decision making paradigm, where clinicians and patients, in partnership, are encouraged to construct an agreed upon treatment plan that may or may not include an exercise program (308). From a practical standpoint, clinicians are liberated from the traditional treatment targets of improving muscle strength or restoring scapulo-humeral rhythm, because there is no evidence supporting their causal link to a successful clinical outcome. Clinicians remain justified in targeting these physical impairments if they and the patient desires, and it fits with their clinical reasoning and the patient's clinical presentation, however, they are not limited to these overly simplistic

treatment narratives. Clinicians are also encouraged to embrace a pluralistic approach to exercise type, where they can freely choose between various exercise types and dosages depending on the clinical situation, rather than being beholden to one particular approach or dose. Qualitative research reveals that exercise is often wanted and well received by individuals with lived experience of RCRSP, as long as it's provided in the appropriate context (Chapter 6), explained and demonstrated adequately, the equipment required is accessible, and does not impose an exercise burden. Overall, exercise therapy remains a principal treatment option for individuals with RCRSP, despite uncertainty underpinning much of its delivery.

The narrative review, presented in Chapter 8, uses the Bradford Hill viewpoints of causality to evaluate the causal claim of exercise therapy for RCRSP. The aim of this review was to apply an alternative framework of causation, Hill's viewpoints, to exercise therapy for RCRSP that includes evaluation of both mechanistic and probabilistic evidence. It was hypothesised that this would provide a more rounded perspective on the relationship between exercise and shoulder pain relief rather than exclusively relying on effect sizes derived from RCTs. After narratively reviewing the evidence-base, the causal claim of exercise therapy for reducing shoulder pain was inconclusive. There are other plausible explanations which may account for the association between exercise and shoulder pain relief, such as non-specific and contextual effects and bias. Furthermore, there is an inconsistent and context-dependent association between exercise therapy and shoulder pain relief, heterogenous use of diagnostic labels and selection criteria, and poor reporting of the exercise program under investigation. There does not appear to be a dose-response relationship between exercise and pain relief, evidence of mechanisms, whilst biologically plausible, are lacking, and the overall strength of association is modest. Applying Hill's viewpoints facilitated a comprehensive evaluation of the causal claim of exercise therapy for RCRSP, and in doing so, established that the effectiveness of exercise therapy remains opaque, with some categories of causality largely satisfied and other not. It must be acknowledged, based on the results of this review, that the association between exercise and shoulder pain relief could be unrelated, or trivially related, to the specific targets of the exercise program, and this warrants further investigation.

9.4 STRENGTHS AND LIMITATIONS

To the best of author's knowledge, the studies included in this research program are original in their aim and scope and make a significant contribution to the literature as it pertains to investigating the causal mechanisms of exercise therapy for RCRSP. Given the immaturity of the causal mechanism literature in general, the studies within this thesis represent foundational pieces of research, which may assist future research endeavours.

The editorial of this thesis (Chapter 3) was published in a high impact peer reviewed Quartile 1 journal, *Journal of Orthopaedic and Sports Physical Therapy*, and was the first of its nature to provide a critical commentary on how and why resistance exercise may or may not help individuals with RCRSP. The editorial has been highly cited and impactful since publication, ranking in the 99th percentile of all publications tracked by Altmetric.

The scoping review of this thesis (Chapter 4) was published in the peer reviewed Quartile 1 journal, *Musculoskeletal Science and Practice*. The review was pre-registered on the Open Science Framework and adhered to PRISMA-ScR guidelines. The scoping review was the first of its type published in the shoulder evidence-base, extending previous findings of other comparable studies in the chronic low back pain and knee osteoarthritis literature. Together, these reviews form an important body of knowledge regarding the prevailing view of how and why exercise is believed to help individuals with various musculoskeletal pain presentations. A scoping review was the chosen review method because of the underdeveloped causal mechanism literature, which precluded a systematic review. As the literature develops, a systematic review will become more feasible. A scoping review is a robust review method in its own right, and is especially useful when the aim of a study is to identify and map the available evidence, and when the available evidence is emerging rather than established (387).

The survey of this thesis (Chapter 5) was published in a peer reviewed Quartile 2 journal, *Musculoskeletal Care*, and adhered to the CROSS guidelines (236). A survey was chosen as the preferred method in order to access a large number of physiotherapists from around the world. This enabled the recruitment of a substantial number of participants, 480, from diverse countries and continents, which made the conclusions stronger and more generalisable. The number of participants in this study was comparable with other surveys of physiotherapist practice in the shoulder literature (94), and in some cases was much more significant (282).

The qualitative study of this research program (Chapter 6) was published in a high impact Quartile 1 peer reviewed journal, *Physical Therapy and Rehabilitation Journal*, and adhered with the Standards for Reporting Qualitative Research (264). This qualitative study used several techniques to enhance the trustworthiness of its findings, including declaring researcher characteristics, using multiple interviewers and data coders, conducting a pilot interview, and sending out preliminary causal explanations/themes to participants for an opportunity to provide feedback (member checking). To the best of the authors knowledge, this was the first qualitative study to specifically explore the causal mechanisms of exercise therapy for musculoskeletal pain from a first-person patient perspective. This study was strengthened by the use of a critical realist

theoretical foundation, which facilitated the study of contextual factors that may trigger or inhibit the activation of identified causal mechanisms. Since the publication of this study, a review has been published using a critical realist approach exploring exercise therapy for persistent low back pain, which reported similar findings to our study (386), which adds credibility to our study. The identification of causal mechanisms and their related contextual features is an original contribution to the exercise therapy for musculoskeletal pain literature and may have implications for clinical practice.

The mixed methods employed in this research program, underpinned by a critical realist philosophy of science, can be considered a strength of this thesis. By exploring the views of varied stakeholders using appropriate methods (review, survey, interviews) allowed for a comprehensive appraisal of the prevailing views of how exercise is perceived to help individuals with RCRSP. This would not have been possible by using a pure positivist or constructivist approach. The critical realist philosophy facilitated the consideration of context and its influence on identified causal mechanisms, which is contrary to traditional physiotherapy and health science research that typically employs a strict positivist approach (388). However, critical realism still embraces a realist ontology, meaning things actually happen and real mechanisms actually generate events, although this is largely influenced by context (142). It is the combination of a realist ontology and an interpretivist epistemology that give critical realism its robustness as a method and utility when investigating causal questions (146, 267). This research program is specifically concerned with a causal question, “how and why is exercise therapy beneficial for individuals with RCRSP”? Critical realism provides a suitable philosophical framework through which to pursue this question, as critical realism employs retroductive reasoning, which aims to explain events and complex phenomenon by postulating and identifying mechanisms which are capable of producing them (146). Thus, the marriage of the primary research question of this thesis with a critical realist philosophical approach provides a strong theoretical foundation for this research program.

The critical review of this thesis (Chapter 7) was published in a peer reviewed Quartile 2 journal, *Musculoskeletal Care*. This study was a narrative review that aimed to bring together the vast swathe of mixed method evidence, critically appraise it, and provide practical considerations for clinicians when delivering exercise therapy in their practice. This study was the first of its type to specifically and critically explore exercise therapy for RCRSP considering diverse evidence types and attempt to distil the voluminous and ultimately uncertain evidence-base into practical considerations for clinicians. A strength of this study was its scope, incorporating qualitative and quantitative studies, and broaching many dimensions of exercise therapy, including exercise dosing

parameters, causal mechanisms, magnitude of effect, and possible barriers and facilitators of adhering to an exercise program. The critical nature of this study meant that it aimed to analyse the available evidence in an unbiased and honest manner, in order to paint an accurate picture of the current landscape of using exercise to manage RCRSP.

The final study of this thesis (Chapter 8), under review at *Shoulder and Elbow*, is an original narrative review using the Bradford Hill viewpoints of causality to assess the causal claim of exercise therapy for RCRSP. This study is the first of its kind in the shoulder literature, and one of only a handful in the field of health science and medicine to seriously use Hill's viewpoints to analyse the causal claim of an intervention. Hill's viewpoints are an institution in the field of epidemiology and philosophy of medicine and are considered a rigorous framework to evaluate causality in the presence of inconclusive RCT evidence and for the evaluation of non-pharmacological interventions (133, 168). In accordance with the principles of EBM+ and critical realism, using Hill's viewpoints of causality facilitated a comprehensive analysis of the literature in attempt to answer the question: "what is the best explanation for the association between exercise therapy and a reduction in shoulder pain when considering both probabilistic and mechanistic evidence?". Applying a causal framework that has been used in epidemiological research for over 50 years to the shoulder evidence-base ensures a robust theoretical foundation to this study.

Despite the strengths of this thesis, and as with any research endeavour, it has limitations. A scoping review was conducted rather than a more highly rated systematic review, because of deficiencies in the evidence-base. A scoping review, whilst a sound method in its own right, is judged to be not as rigorous as a systematic review but can serve as a prelude to performing a systematic review at some later time (387). The survey within this thesis also has some limitations. Whilst the survey successfully managed to recruit participants from diverse countries and backgrounds, the majority were male, working in private practice, and from an English speaking and highly economically developed country. The qualitative study recruited a sample of 11 participants, which may be perceived as small. However, this would be looking at sample size through a quantitative research lens, which is fundamentally different to the goals of qualitative research. In our qualitative study, we used theoretical sufficiency to decide when to cease recruitment, which is based less on gross numbers and more on how meaningful the data appears (270). The critical review of Chapter 7 and review of Chapter 8 are narrative in nature. A narrative review, again, is judged to be inferior to a systematic review, however, due to the overarching scarcity of research concerning the causal mechanisms of exercise for RCRSP, and the original and

wide-ranging scope of these studies, a narrative review was considered the most appropriate review method.

9.5 CLINICAL IMPLICATIONS

This research program has produced knowledge that may benefit clinicians in their practice. Firstly, it appears that popular treatment targets of exercise, including muscle strength, posture, acromiohumeral distance, and motor control are not clearly related to improvements in shoulder pain and function through an exercise program. Rather than submitting to clinical nihilism, this finding may instead liberate clinicians from overly prescriptive and algorithmic approaches to exercise and encourage the clinician to meet the patient where they are and identify where they want to go. It opens up a pluralistic approach to exercise prescription, where many different types of exercises and dosages can be usefully employed to produce positive clinical outcomes for an individual with RCRSP. Much will depend on the person, their circumstances, their beliefs and past experiences with exercise, their goals, and their current symptom irritability profile, rather than prescribing an exercise at a certain time because that's the way they were taught or because of some imprecise biomechanical clinical rationale. Specificity of exercise prescription is not redundant but does not seem to matter for reducing the pain experience. Where specificity may be more influential is optimising performance of the shoulder, perhaps in readying an individual to return to sport or work, where there is a significant expected physical demand on the shoulder.

Another key finding of this research program is the importance of clinical context. Clinicians and patients tend to care about one thing, reducing pain so they can return to meaningful activity. Clinicians often achieve this outcome via the prescription of an exercise program, and as such are often overly concerned with the specifics of the exercise program itself. What is the optimal dose? What is the optimal exercise type? Should pain be tolerated? Supervised or home program? The list goes on. The science of exercise prescription has a rich literature and there is much to consider from a programming perspective. However, when it comes to shoulder pain relief in individuals with RCRSP, the specifics of an exercise program may matter less than the clinical context within which the program is prescribed. A clinician may curate a perfectly evidence-based exercise program, with every detail accounted for down to the last set and rep, however if that clinician does not first foster a strong working therapeutic relationship with the patient facing them, the causal power of that program may not manifest. Moreover, if a patient perceives their prescribed program to not be appropriately tailored to their specific clinical presentation, it may not be effective. The success of an exercise program is context dependent. It is not something that can be parachuted into a clinical encounter with a resultant predictable outcome. It is relational, dynamic,

living, and involves shared decision making. By appreciating the extent to which context matters, clinicians can harness this to first build trust and a strong therapeutic relationship, consider involving the patient in the construction of their program, tailor the program to the needs of the patient, and not be afraid to experiment with different types of exercise and movement strategies.

Whether clinicians should permit the experience of pain during an exercise program, whether it should be supervised or not, and if they should consider providing adjunctive therapies, such as manual therapy, is not clear. There is currently no strong and consistent evidence that suggests allowing or disallowing the experience of pain during an exercise program is superior or inferior. The same goes for supervised versus independent exercise therapy. Current evidence suggests no statistical or clinical differences between either type of program. Manual therapy could be provided, or not, with current meta-analyses reporting no difference between exercise alone and exercise plus manual therapy. The overarching theme appears to be, to use a popular physiotherapy adage, it depends. Leaning into a shared decision-making paradigm can reduce the anxiety produced by the uncertainty which underscores much of exercise prescription in clinical practice. In the absence of robust evidence that provides strong recommendations to provide one treatment over another, shared decision-making is the preferred method of navigating clinical uncertainty. Once again, this research program has highlighted there really is no best exercise approach, at scale, for all individuals with RCRSP. However, there may be a ‘best’ exercise program for a particular individual, and it is the task of the clinician and patient, together, to work out the specifics of this hypothetical program. Arriving at an effective program for an individual may involve the use of exercise experiments, which involves a systematic trial and error approach to exercise prescription. This allows clinicians to move freely between exercise types and dosages based on the response of the individual and does not assume that all individuals will respond the same way. In this way, clinicians are able to construct a tailored exercise program that matches the clinical presentation and goals of their patients, whilst still acknowledging the inherent uncertainty of an individual’s shoulder pain experience and possible response to an exercise program.

9.6 FUTURE RESEARCH DIRECTIONS

9.6.1 *Testing purported mechanisms of exercise.*

This research program has identified and collated the causal mechanisms that are believed to underpin the clinical effectiveness of exercise for RCRSP. These mechanisms were gathered from diverse stakeholders (researchers, clinicians, patients) using varied research methods. However, whilst many mechanisms have been identified, there remains very little research that employs appropriate statistical methods, such as mediation analysis, to test whether these commonly

proposed mechanisms mediate clinical improvements in shoulder pain, function and disability in response to an exercise program. Future research should consider complementing RCTs with mediation analysis to test how exercise works, not just does it work. This could be done by consulting the commonly proposed mechanisms identified in this research program.

Future research might also consider conducting more basic science mechanistic research, particularly exploring the biochemical response of the rotator cuff and related structures to an exercise program. This may serve to enhance our understanding of the possible biochemical basis to an improvement in shoulder pain and function through exercise therapy.

9.6.2 Considering context

Future research should consider the role of context in influencing clinical outcomes. This may be amenable to conducting a realist review, which has philosophical roots in critical realism (389), to understand the broad relationship between exercise therapy-context-mechanism-outcome. This review may build upon the qualitative study of this research program (Chapter 6) by bringing together both qualitative and quantitative research to gain a macroscopic understanding of the causal relationship between exercise therapy – clinical context – causal mechanisms and clinical outcomes. This may allow for a nuanced understanding of how clinical context causally influences outcomes by triggering or inhibiting the activation of causal mechanisms.

9.6.3 Placebo controlled trial

This research program identified only one high quality randomised placebo-controlled trial comparing a combination of exercise therapy and manual therapy with a realistic placebo (de-tuned ultrasound). This trial has been criticised for its choice of both intervention and control groups. Future research may consider conducting another randomised placebo-controlled trial comparing an exercise program with a sham exercise program. This may involve comparing progressive resisted exercise with unloaded exercise as per Holmgren et al. 2012 (316), but in a more rigorous fashion. This would allow robust testing of the hypothesis that ‘getting stronger’ through progressive resistance exercise is a mediator of clinical outcomes for individuals with RCRSP. Similarly, this could be done for motor control exercise compared to sham exercise.

9.6.4 Standardising diagnostic labels and selection criteria

Future research may seek to recommend a standardised diagnostic label and selection criteria to use in clinical research. This may allow for more consistent research into exercise for RCRSP across countries and research groups, potentially producing more reliable results. This may be achieved via a consensus study using Delphi methods.

9.6.5 *Better reporting of exercise parameters*

The reporting of exercise parameters in the RCRSP literature is poor. This currently impairs interpretation and replication of the majority of clinical research. Future research should, as a priority, make a concerted effort to fully detail the exercise program used in their research program by adhering to the CERT and TIDieR checklists. This is paramount in future research endeavours, because if we want to know the effectiveness of some treatment, we must know precisely how the treatment was planned, implemented, and carried out. Journals and peer reviewers would do well to screen proposed manuscripts with this in mind too.

9.7 THESIS CONTRIBUTIONS

This thesis has contributed to the research literature regarding exercise therapy for RCRSP. This includes original contributions to the literature specifically exploring how and why exercise may or may not work for RCRSP. The scoping review, survey of clinicians, and qualitative studies of this thesis are pioneering and are the first to explore the commonly held views of researchers, clinicians, and patients about how exercise is perceived to help reduce shoulder pain. The results show that exercise is commonly believed to be effective for RCRSP via biomechanical constructs, despite a lack of supporting evidence. However, patients and clinicians are more likely to also propose psychological variables, which was an interesting finding. The critical review of this thesis (Chapter 7) integrates a broad spectrum of research to provide practical and theoretical recommendations for clinicians to consider in their practice. The critical review shows that exercise can be successfully delivered in practice despite uncertainty underpinning much its theory, which clinicians may find helpful. The narrative review of Chapter 8 used the Bradford Hill viewpoints to holistically investigate the causal claim of exercise therapy for RCRSP. This is the first of its kind in the shoulder literature, and one of very few in musculoskeletal research more broadly. This study shows that exercise currently has a tenuous causal relationship with a reduction in shoulder pain. This research program represents a comprehensive exploration of the possible causal mechanisms of exercise therapy for RCRSP and has produced numerous novel studies and generated new knowledge. This body of work may be used as a foundation for future research that wished to investigate the causal mechanisms of exercise for RCRSP, which is encouraged. Because of the scarcity of research on the causal mechanisms of exercise for RCRSP at the commencement of this research program, much of this thesis is concerned with identifying, collating, surveying, organising and scoping the current evidence landscape. Therefore, this thesis has advanced knowledge not by solving the problem of how and why exercise works for RCRSP, which was impossible owing to lack of research in the area but has organised the literature to allow it to be better understood,

generated new knowledge about the problem, and even analysed the problem from a novel perspective (Bradford Hill viewpoints). Thus, the problem has been altered and minimised, which is in itself an advance and a sign of progress. Much work remains because science is an infinite game, and it's also the best game in town. I will end this thesis with a quote from the philosopher Karl Popper, which poetically captures this sentiment:

“A change of emphasis [of a problem] may make all the difference not only to our understanding but to the problem itself, to its fertility and significance, and to the prospects of an interesting solution. It is important for a scientist to be awake to these changes and shifts and not to make them either unconsciously or surreptitiously for it often happens that a reformulation of a problem can reveal to us almost the whole of its solution”. Karl Popper (390)

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APPENDICES

APPENDIX 1: INFOGRAPHIC FOR VIEWPOINT



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RESEARCH ARTICLE

WILEY

Physiotherapists nearly always prescribe exercise for rotator cuff-related shoulder pain; but why? A cross-sectional international survey of physiotherapists

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Abstract

Background and Aims: This cross-sectional international survey explored the beliefs of physiotherapists regarding the possible mechanisms of benefit of exercise for rotator cuff-related shoulder pain (RCRSP). Clinical practice guidelines recommend physiotherapists use exercise as a primary treatment to help people with RCRSP, but the explanations provided to patients by physiotherapists regarding its mechanism of effect is unknown.

Materials and Methods: Registered physiotherapists were surveyed about 'how and why' they believe exercise provides a clinical benefit for people with RCRSP. Information was also gathered about commonly used exercise types and preferred diagnostic labels. The survey was designed and reported in concordance with Consensus-Based Checklist for Reporting of Survey Studies guidelines.

Results: Four hundred and eighty physiotherapists from forty-nine countries completed the survey. Psychosocial and biomedical mechanisms of exercise were evenly selected by participants. Improving muscle strength, muscle endurance, pain self-efficacy and reducing kinesiophobia, and fear avoidance beliefs were the most common individual mechanisms thought to underpin exercise therapy for RCRSP. Rotator cuff-related shoulder pain was the most commonly used diagnostic label.

Discussion and Conclusion: Physiotherapists hold beliefs regarding exercise mechanisms that is largely concordant with the current evidence base, which is commendable. Future research should consider the patients perspective and consider testing commonly selected mechanisms of exercise, such as shoulder muscle strength, pain self-efficacy and kinesiophobia as possible mediators of recovery.

KEYWORDS

exercise, exercise mechanisms, physiotherapy, rotator cuff, shoulder pain, strengthening

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1

1 | INTRODUCTION

Shoulder pain is common and impacts on myriad functions of life (Page et al., 2019; Urwin, 1998). Rotator cuff-related shoulder pain (RCRSP) is reported to be the most frequent manifestation of shoulder pain (Luime et al., 2004) and unfortunately can prove resistant to medical, surgical and non-surgical interventions. The veracity and usefulness of RCRSP as a diagnostic label for shoulder pain has been explored elsewhere (Lewis, 2016; Lewis & Powell, 2022; Lo et al., 2022a; Requejo-Salinas et al., 2022; Zadro, 2021) and is beyond the scope of this study.

Many treatments, with similar effectiveness, exist to help people suffering with RCRSP. Of the treatments available, education and exercise therapy are widely recommended as a practical, sensible, and high value first-line intervention (Babatunde et al., 2021; Pieters et al., 2020). Therefore, exercise is the primary focus of this publication. Whilst uncertainty exists regarding the absolute benefit of exercise therapy for managing RCRSP (Page et al., 2016), similar could be said for most (if not all) available treatment options, whether surgical or non-surgical. A possible explanation for the hitherto observed modest clinical effects of exercise for people with RCRSP is the enduring ambiguity of 'how and why' shoulder exercise may influence the experience of shoulder pain. Put simply, if a person experiences an improvement in shoulder pain or function in response to an exercise program, how this occurred is currently unclear. Conversely, if a person doesn't experience a clinical benefit in response to exercise, we often don't know why. This lack of knowledge about treatment mechanisms is not limited to exercise or to the shoulder (Lee et al., 2016) and is an area of burgeoning research interest (Nguyen et al., 2020). Biopsychosocial mechanisms underpinning exercise for musculoskeletal conditions have been proposed (Smith, 2019), however there is a dearth of research specifically testing these mechanisms for RCRSP.

Research has been conducted investigating the mechanisms proposed by clinical trialists for the beneficial effect of exercise for RCRSP, persistent low back pain and knee osteoarthritis (Beckwee et al., 2013; Powell et al., 2022; Wun et al., 2020). Despite this, to the best of the authors knowledge, no research to date has explored the beliefs of practising physiotherapists regarding the possible causal mechanisms of exercise therapy for managing RCRSP. This is despite the overwhelming majority (up to 99.8%) of physiotherapists reporting they would prescribe exercise for people presenting with signs and symptoms resembling RCRSP (Smythe et al., 2020). Understanding clinician perspectives is important because it is the clinician who is tasked with providing explanatory information about the available treatments during shared decision making. In turn, it is often these explanations that patients latch onto (Setchell et al., 2017), which have the potential to influence perceptions of their condition.

Given the role physiotherapists undertake in helping people with RCRSP, most often via the prescription of exercise, the primary aim of this study was to explore how physiotherapists believe exercise

may provide benefit for individuals with RCRSP. Secondary aims were to compare the beliefs of practising physiotherapists with mechanisms proposed by clinical trialists, and to determine whether there is a difference between physiotherapists with and without a special interest in musculoskeletal shoulder pain pertaining to whether they believe biomedical or psychosocial mechanisms most often underpin exercise therapy.

2 | METHODS

2.1 | Design

This study is a cross-sectional online international survey exploring physiotherapists beliefs of the possible mechanisms underpinning exercise therapy in the management of RCRSP. The design of this study was partly inspired by a previous published survey exploring physiotherapy practice for RCRSP (Bury & Littlewood, 2018). The design was chosen to capture, globally and at scale, the average viewpoint of physiotherapists regarding mechanisms of exercise for RCRSP. The design and reporting of this survey is concordant with the Consensus-Based Checklist for Reporting of Survey Studies (CROSS) guidelines (Sharma et al., 2021).

2.2 | Ethics

Ethical approval for this survey was obtained by the Bond University Human Research Ethics Committee (JP03070).

2.3 | Survey development

The authors developed an original 22-item survey (Appendix 1) using Qualtrics software (Qualtrics, Provo, Utah) guided by the results of a recent scoping review of commonly suggested mechanisms of exercise for RCRSP as proposed in clinical research (Powell et al., 2022). The survey was divided into three main sections. Section one was designed to capture participant demographic information. Section two was designed to identify the beliefs of physiotherapists about the possible mechanisms underpinning exercise therapy for RCRSP. Section three was designed to elicit information about the practice of measuring shoulder strength, what diagnostic labels physiotherapists use to describe a clinical presentation resembling RCRSP and whether knowledge of treatment mechanisms was important to their clinical practice. The survey employs the use of a clinical vignette to help orient participants towards a 'typical' clinical presentation of RCRSP. The clinical vignette was adapted from Bury & Littlewood, 2018 (Bury & Littlewood, 2018) and is documented in Box 1 below. The pretesting process of the survey was 2-staged and involved 15 physiotherapists. Stage 1 involved pretesting the survey with 5 registered physiotherapists in Australia (male = 4, female = 1),

after which minor amendments were made to the wording and structure of survey questions to improve flow. Stage 2 involved pretesting the survey with 10 (male = 6, female = 4) registered physiotherapists from Australia ($n = 5$), United Kingdom ($n = 2$), North America ($n = 2$) and Thailand ($n = 1$) and appropriate minor modifications were made to wording and adding skip logic functions where necessary.

Box 1 Clinical vignette

A 52 year-old man presents to you with a 6-month history of non-traumatic, gradual onset, right-sided shoulder pain. The man works as a financial planner and thus is not engaged in labour intensive work. The pain is predominately confined to the anterolateral region of the shoulder. There are no radiculopathy symptoms or referral of pain down the arm or up the neck. Pain intensity is mild to moderate in nature, rising to 5/10 at worst and is negligible at rest. Pain type is typically dull unless aggravated, in which the pain can become sharper. Aggravating factors are shoulder abduction (painful arc sign), reaching behind the back and sleeping on the affected side. There is no history of shoulder dislocation or feelings of instability. Passive range of motion (ROM) of the shoulder is preserved. Shoulder external rotation strength, as measured by a hand-held dynamometer, is reduced by 20% on the affected side vs. the unaffected side but a massive full thickness rotator cuff tear is not suspected. Cervical spine ROM is full and pain free. The acromioclavicular joint is unremarkable. An ultrasound scan of the affected shoulder has been performed, which reveals tendinopathy of the supraspinatus and thickening of the subacromial bursa. There are no relevant co-morbidities. The pain is impacting the man's quality of life, mainly disrupting sleep and the ability to participate in his weekly tennis.

2.4 | Sampling and recruitment

Physiotherapists were able to participate in this study if they were, (1) registered with their national accrediting body, (2) at the time of the survey were treating people seeking care for shoulder pain, (3) aged 18 years and above, and (4) were proficient in the English language. Convenience sampling was used to recruit potential participants via the social media platforms Twitter™, Instagram™ and Facebook™. One month after the initial advertisement of the survey on the social media platforms, a reminder was posted to prospective participants. This recruitment strategy was hypothesised to be sufficient to obtain a sample size of ≥ 350 participants, which was adequate in previous comparable research (Bury & Littlewood, 2018;

Smythe et al., 2020). The survey was live online between March 30 and 9 May 2022.

2.5 | Statistical analysis

Data was collected via Qualtrics software (Qualtrics) and exported to SPSS v28 (IBM Corp) for statistical analysis. We set a threshold that minimum 60% of the survey be completed to be included in the final analysis. Descriptive statistics were used to summarise the data and Chi-square tests (alpha 0.05) were used to compare those with and without a special interest in shoulder pain for whether they thought biomedical or psychosocial factors most often underpinned the effect of exercise for RCRSP. Qualitative responses were categorised into cogent themes using thematic analysis (Braun & Clarke, 2006) and, where appropriate, incorporated into the main dataset.

3 | RESULTS

A total of 660 physiotherapists returned responses to the survey. One hundred and eighty responses were excluded for completing less than 60% of the survey, leaving 480 responses for inclusion in the final analysis (73% of the original sample). Figure 1 illustrates the flow of participants through this study. The survey took approximately 10 min to complete.

The demographic information of the participants in this study is displayed in Table 1 (see end for list of tables). Most respondents were male (61.3%), from Australia/New Zealand (38%), worked in private practice (72.1%) and indicated they had a self-reported special interest in shoulder pain (65.2%). The participants were from 49 different countries and all but one continent (Antarctica) was represented (Figure 2).

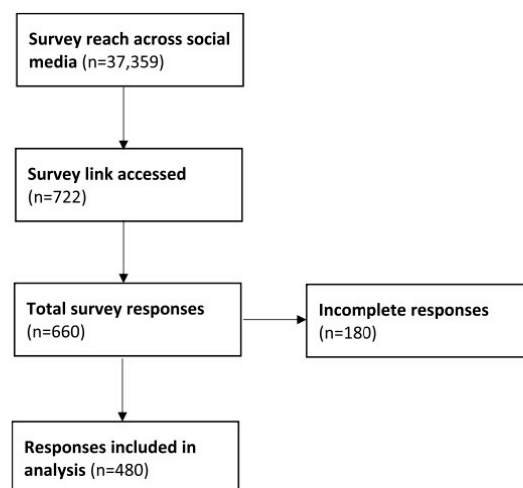


FIGURE 1 Flow of participants through study

TABLE 1 Participant demographic information

	Mean (range)	Standard deviation
Age ^a	34.2 (20–66)	9.8
Gender	Frequency (n)	Total (%)
Male	294	61.3%
Female	185	38.5%
Non-binary/third gender	1	0.2%
Total	480	100%
Clinical experience		
<5 years	204	42.5%
5–10 years	83	17.3%
10–15 years	65	13.5%
15–20 years	44	9.2%
>20 years	84	17.5%
Total	480	100%
Location of registration		
Australia and New Zealand	182	38%
Continental Europe	119	25%
Great Britain and Ireland	88	18%
Northern America	56	12%
South America	2	0%
Middle East and Northern Africa	11	2%
Southern Africa	4	1%
Asia	18	4%
Total	480	100%
Average number of shoulder pain cases treated per week		
Less than 5	108	22.5%
5–10	248	51.6%
11–15	71	14.8%
>15	53	11%
Total	480	100%
Clinical setting ^b		
Private practice	344	72.1%
Hospital inpatients	6	1.3%
Hospital outpatients	90	18.9%
Aged care facility	2	0.4%
Community health	25	5.2%
Professional sport	10	2.1%
Total	477	100%
Special interest in MSK shoulder conditions		
No	167	34.8%
Yes	313	65.2%
Total	480	100%

^aBased on 432 respondents.^bBased on 477 respondents.

3.1 | Would you prescribe exercise for this clinical presentation?

Almost all (99%) respondents indicated they would prescribe exercise for the type of presentation described in the clinical vignette.

3.2 | Exercise type

Resistance exercise was the most common type of exercise physiotherapists would prescribe for the clinical presentation described in the vignette (288/474; 60.8%). Resistance exercise was selected approximately three times more often than the next most common type of exercise, motor control exercise (102/474; 21.5%) (Figure 3). The most common 'other' exercise type was a combination of exercise types (19/474; 4%).

3.3 | Exercise mechanisms

Respondents selected a balanced variety of mechanisms to explain the clinical effectiveness of exercise for RCRSP. Psychosocial factors were selected most often (325/472; 68.9%) followed by

neuromuscular factors (289/472; 61.2%), neurophysiological factors (58.3%) and tissue healing factors (45.3%) (Figure 4). 'Other' mechanisms were proposed rarely (8/472; 1.7%) with the most common being a combination of all suggested mechanisms (6/8; 75%).

Among neuromuscular mechanisms, increased muscle strength ($n = 293$), muscle endurance ($n = 239$) and enhanced shoulder motor control ($n = 238$) were the most selected mechanisms to explain possible improvements in shoulder pain and function with shoulder exercise. An increase in acromiohumeral distance was the least selected mechanism ($n = 19$) (Figure 5a).

Psychological mechanisms were deemed important by the vast majority of respondents (431/475; 90.7%). The specific psychological mechanisms selected were relatively evenly spread; with kinesiophobia ($n = 354$), pain self-efficacy ($n = 308$), and fear avoidance beliefs ($n = 306$) the most selected psychological mechanisms to explain the possible effectiveness of shoulder exercise. Depression ($n = 83$) and anxiety ($n = 129$) were selected the least (Figure 5b).

When dichotomised into either biomedical or psychosocial mechanisms to explain the effect of shoulder exercise, psychosocial mechanisms (249/473; 52.6%) were selected slightly more often than biomedical mechanisms (224/473; 47.4%). Respondents with a self-reported special interest in musculoskeletal shoulder pain were significantly more likely to select psychosocial mechanisms (173/307;



FIGURE 2 Countries represented in the survey

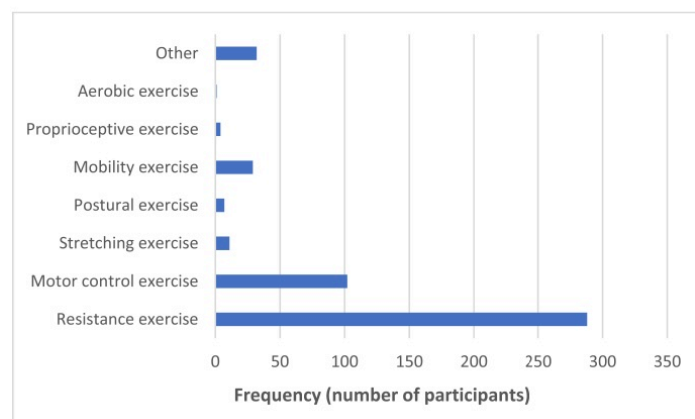


FIGURE 3 Exercise types selected to manage the presentation described in the clinical vignette

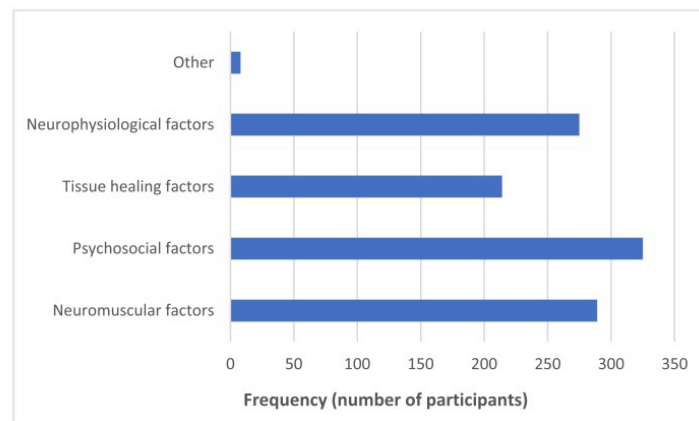


FIGURE 4 Mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette

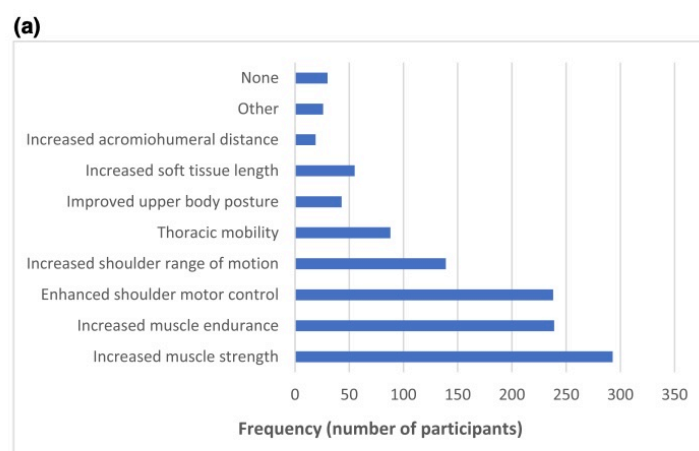
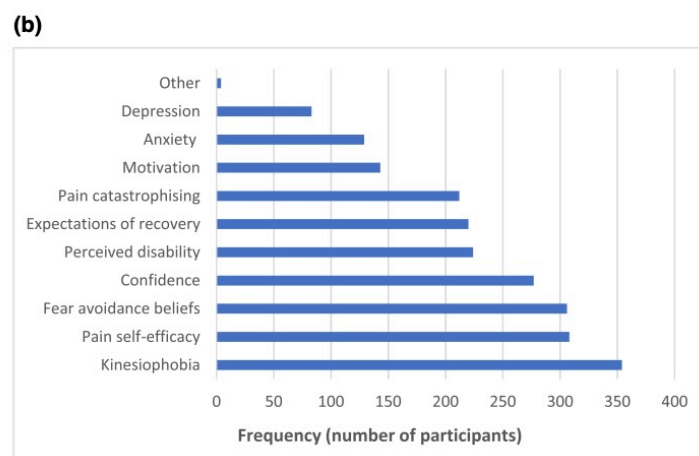


FIGURE 5 (a) Neuromuscular mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette, (b) Psychological mechanisms selected by physiotherapists to underpin exercise for the presentation described in the clinical vignette



56.4%) than those without a self-reported special interest (76/166; 45.8%) (Chi-Squared = 4.8, $p = 0.028$).

Physiotherapists were uncertain regarding the importance of tissue healing mechanisms in response to exercise for shoulder pain, with approximately half believing it is important (234/457; 51%) and half believing it is not important (223/457; 49%). In contrast, most physiotherapists in this cohort (394/455; 87%) believe neurophysiological factors to be an important mechanism underpinning exercise.

3.4 | Scapular dyskinesis

Most physiotherapists in this cohort (303/461; 66%) did not believe that an identified scapular dyskinesis need be rectified or optimised for shoulder pain and function to improve.

3.5 | Shoulder weakness

Most physiotherapists in this cohort (275/459; 60%) believed the external rotation weakness described in the clinical vignette should be a primary target for treatment.

3.6 | Posture

Slightly more physiotherapists in this cohort (266/462; 58%) did not believe that any detected postural abnormalities of the shoulder complex (including the thoracic spine) to be an important treatment target.

3.7 | Shoulder strength measurement

Most physiotherapists in this cohort (355/463; 77%) indicated they regularly measure shoulder strength in their clinical practice. The most common method of measuring maximal shoulder strength was manual muscle testing (MMT) (193/348; 56%) followed by handheld dynamometry (113/348; 33%) and isokinetic testing (20/348; 6%). 'Other' methods suggested by respondents included using a force frame ($n = 8$) and using various repetition maximum tests ($n = 7$).

3.8 | Diagnostic label

Most physiotherapists in this cohort (267/454; 59%) selected RCRSP as the diagnostic label they would use for the clinical presentation described in the vignette (Figure 6). Rotator cuff-related shoulder pain was selected four times more often than the next most common diagnostic label, subacromial pain syndrome (62/454; 14%) and rotator cuff tendinopathy (51/454; 11%). The traditionally common diagnostic labels subacromial/shoulder impingement syndrome (18/454; 4%), shoulder bursitis (2/454; 0.4%) and rotator cuff disease (1/

454; 0.2%) were selected relatively infrequently. Some respondents suggested 'other' diagnostic labels including sensitive shoulder ($n = 2$), shoulder irritation ($n = 2$), and weak and painful shoulder ($n = 1$).

3.9 | Knowledge of exercise mechanisms

The vast majority of participants in this survey (408/455; 90%) indicated that more knowledge on the possible mechanisms of exercise for shoulder pain would benefit their clinical practice.

4 | DISCUSSION

The results of this international cross-sectional survey suggest physiotherapists hold beliefs regarding exercise mechanisms for RCRSP that is largely concordant with the current evidence base. In fact, it appears practicing physiotherapists, in this cohort, hold beliefs regarding the possible mechanisms of exercise that more closely approximates contemporary scientific research compared to the explanations proffered in randomised clinical trials (Powell et al., 2022).

Almost all (99%) physiotherapists who participated in this survey indicated they would prescribe some form of exercise for a clinical presentation resembling RCRSP. This is similar to previous published surveys of physiotherapists from around the world (Bury & Littlewood, 2018; Pieters et al., 2019; Smythe et al., 2020) and is consistent with recommendations from both clinical practice guidelines (Hopman, 2013) and systematic reviews (Haik et al., 2016; Pieters et al., 2020; Steuri et al., 2017). Uncertainty remains regarding the absolute effectiveness of exercise for RCRSP (Page et al., 2016) and this study does not address or mitigate this uncertainty, however, physiotherapists in this cohort do adhere to recommendations in the scientific literature. Resistance exercise was clearly the most common type of exercise physiotherapists would prescribe for people with RCRSP and was three times more common than motor control exercise. It is unclear why resistance exercise was clearly the most popular exercise type to manage RCRSP. Resistance exercise to 'strengthen' muscles of the shoulder complex is a recommended intervention (Haik et al., 2016) and is possibly effective for people with RCRSP (Naunton et al., 2020) but it is unclear if resistance exercise is clinically superior to motor control exercise (Lafrance et al., 2021). Perhaps simple progressive resistance exercise is considered a more parsimonious exercise approach to manage RCRSP and there is evidence that perceived complexity can be a barrier to initiating and maintaining participation in exercise (Winnett et al., 2009).

Physiotherapists surveyed in this study, somewhat surprisingly, selected psychosocial mechanisms of exercise more often than biomedical mechanisms. In fact, 91% of physiotherapists believe psychosocial constructs to be important mechanisms underpinning the possible effectiveness of exercise for RCRSP. This is in complete contrast to a recent scoping review investigating proposed

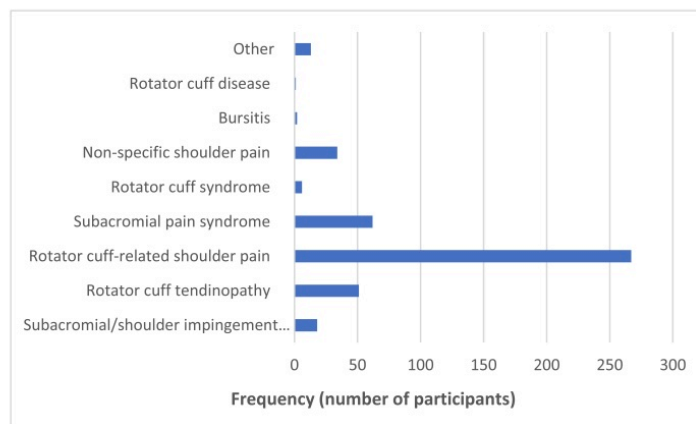


FIGURE 6 Diagnostic label preferred by physiotherapists to describe the presentation in the clinical vignette

mechanisms of benefit of exercise for RCRSP in randomised clinical trials (Powell et al., 2022). This scoping review reported only 5% of all proposed mechanisms of exercise in clinical research were related to psychosocial constructs (Powell et al., 2022). This appears to indicate that practising physiotherapists might hold a more rounded understanding of the probable multifactorial causal effect of exercise for RCRSP compared to clinical researchers and reiterates appeals for clinicians and researchers to work together in the research process (Esculier et al., 2018). Kinesiophobia, pain self-efficacy and fear avoidance beliefs were the specific psychological mechanisms selected most often. These psychological constructs appear to be associated with clinical outcomes in people with shoulder pain (Chester et al., 2018; Luque-Suarez et al., 2019; Martinez-Calderon et al., 2018) but it is unclear to what extent exercise can modify these constructs or if they are valid mediators of recovery for people with RCRSP. There is evidential support in osteoarthritis research for self-efficacy as a mediator of recovery (Lima et al., 2022) and it is plausible this could be the case for RCRSP too (Chester et al., 2019).

Among neuromuscular mechanisms, muscle strength and muscle endurance were most proffered by physiotherapists. This is most likely correlated to resistance exercise being found to be the most popular exercise type to manage RCRSP in this survey. Muscle strength is also a popular causal explanation proposed in clinical research (Powell et al., 2022), indicating agreement between clinicians and clinical researchers. Just how relevant improvements in shoulder strength are in the clinical outcomes of people with RCRSP is currently uncertain (Hotta et al., 2022; Powell & Lewis, 2021) but evidence from knee osteoarthritis research suggests it is a plausible mediator of positive clinical outcomes (Hall et al., 2018). Interestingly, an increase in acromiohumeral distance was the least proposed neuromuscular mechanism in this study, which accurately reflects the evidence base (Park et al., 2020). This diverges from the explanations proffered by clinical researchers (Powell et al., 2022), in which acromiohumeral distance was one of the more common neuromuscular mechanisms proposed. This may suggest, in this cohort at least, clinicians are evolving with the evidence, and this is to be commended.

The importance of tissue healing as a reason to prescribe exercise remains equivocal for the participants in this survey. This probably reflects the lack of consensus in the literature and is an area where research is required. Currently, it appears macroscopic tendon structure need not improve for pain and function to improve (Drew et al., 2014; Ingwersen et al., 2017), however it is plausible that changes in the microscopic biochemical environment of the rotator cuff and subacromial bursa may influence clinical outcomes (Dean et al., 2015). As such, it is unsurprising that 90% of respondents to this survey believe more knowledge on the possible mechanisms of exercise for shoulder pain would support their clinical practice.

Physiotherapists with a self-reported special interest in musculoskeletal shoulder pain were significantly more likely to believe psychosocial mechanisms underpin exercise compared to those without a self-reported special interest. One explanation for this finding could be those with a special interest are more likely to have undertaken further training by attending evidence-based continuing education courses on shoulder pain, or perhaps, are more engaged with contemporary research. This may highlight the importance of keeping up to date with research trends.

Most physiotherapists in this study do not believe scapular dyskinesis or upper body postural abnormalities represent important treatment targets. This belief is backed up by high quality evidence, which suggests that while scapular focused exercise is effective at reducing shoulder pain and improving function, it does not seem to do so via a change in scapular motion (Hotta et al., 2022; Reijnenveld et al., 2017). A recent secondary mediation analysis of a randomised controlled trial (Hotta et al., 2022) reported scapular motion and position did not mediate the effect of scapular focused exercise on shoulder pain and disability in a cohort of people with RCRSP. Moreover, the relationship between static posture and shoulder pain and function are currently tenuous (Barrett et al., 2016). Again, physiotherapists should be commended for holding beliefs that align with contemporary evidence.

Most physiotherapists indicated measuring shoulder force output (strength) was an important part of their clinical practice, and

the most common measurement method was MMT. Manual muscle testing can be a reliable method of measuring shoulder force output (Bohannon, 2018) but is less sensitive and more subjective compared to hand held dynamometry (HHD) and isokinetic testing (Kolber & Cleland, 2013). It is arguably a sensible and pragmatic recommendation for physiotherapists to consider using a HDD, especially given the increasing affordability of these devices (Karagiannopoulos et al., 2022). What clinicians then do with the information derived from the measure is another question entirely, is subject to variation based on the individual clinical context and is the focus of ongoing academic discussion.

The diagnostic label favoured by physiotherapists in this survey was, compellingly, RCRSP. This finding agrees with a recent consensus study of shoulder experts (Littlewood et al., 2019) and reflects the cultural and academic momentum to move away from inaccurate and potentially harmful pathoanatomical diagnostic labels such as subacromial/shoulder impingement syndrome and rotator cuff tear (Lewis, 2016; Lo et al., 2022b; Stewart & Loftus, 2018; Zadro, 2021). Intriguingly, clinicians appear to be more cognisant of current trends in best practice management of shoulder pain compared to researchers, who still overwhelmingly use the term subacromial/shoulder impingement syndrome (Powell et al., 2022).

The findings of this survey must be considered in light of its limitations. We used a convenience sampling recruitment method and were unable to calculate an exact response rate. The survey reached >37,000 potential participants across the social media platforms Instagram™, Twitter™, and Facebook™, however, it is impossible to know what proportion were registered physiotherapists. It is important to acknowledge a possible selection bias too with most participants being male, with a self-reported special interest in shoulder pain, working in private practice and from an English speaking and highly economically developed country. Therefore, the findings of this survey must be interpreted within this context. Moreover, using the authors social media platforms may bias the sample due to familiarity of work. Inherent to de-identified surveys is the problem of screening participants and there is a chance that not all who completed the survey were registered physiotherapists. Whilst the use of clinical vignettes in health research to elicit knowledge, opinions, or attitudes from study participants has many benefits, there are limitations, particularly with external validity (Gould, 1996). We attempted to mitigate this limitation by basing our vignette on published precedents (Bury & Littlewood, 2018; Smythe et al., 2020), thoroughly analysing the evidence-base, and pretesting it to physiotherapists in order make it as generalisable and robust as possible.

5 | CONCLUSION

Physiotherapists in this cohort believe exercise may be effective for RCRSP via a combination of biomedical and psychosocial mechanisms, with a slight leaning towards psychosocial. Improving muscle strength, muscle endurance, pain self-efficacy and reducing

kinesiophobia, and fear avoidance beliefs were the most common individual mechanisms thought to underpin exercise therapy for RCRSP. The term RCRSP was the term of choice identified by respondents of this survey. Subsequent research should attempt to determine if these mechanisms are valid mediators of recovery in response to an exercise program in people with RCRSP.

AUTHOR CONTRIBUTIONS

Jared K. Powell, Ben Schram, Jeremy Lewis, and Wayne Hing conceived and designed the study. Jared K. Powell developed the survey and all authors edited and ratified the final version. Jared K. Powell, Ben Schram and Jeremy Lewis distributed the surveys on social media. Jared K. Powell executed data analysis and all authors critically appraised the results. Jared K. Powell drafted the manuscript, and all authors were involved in the subsequent editing process and approval of the final version of the manuscript.

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CONFLICT OF INTEREST

Jared K. Powell and Jeremy Lewis have received remuneration for the provision of continuing professional development courses on shoulder pain rehabilitation.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available (<https://osf.io/bg3ar/>).

ETHICS STATEMENT

Ethical approval for this survey was obtained by the Bond University Human Research Ethics Committee (JP03070).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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APPENDIX 3: SURVEY AND INFORMED CONSENT

My name is Jared Powell, and I am currently completing a PhD at Bond University under the supervision of Professor Wayne Hing, Professor Jeremy Lewis, and Dr Ben Schram.



I am conducting a research investigation into the mechanisms of exercise for shoulder pain. I am specifically interested in the common explanations proposed by physiotherapists for *how and why* exercise might be effective for the management of shoulder pain.

As part of this study, I will invite you to complete a survey regarding your clinical rationale for prescribing exercise for people with shoulder pain. The survey will take less than 10-minutes to complete.

This study has been approved by the Bond University Human Research Ethics Committee. Project number **JP03070**.

You are eligible to participate if you are:

Age 18 and above, and

- A registered physiotherapist/physical therapist who currently treats people with shoulder pain, and is
- Proficient in written English

Participation in this study is completely voluntary and you may withdraw at any time without risking any negative consequences. If you choose to withdraw your participation in this study, the information you have provided will be immediately destroyed. The information I/we obtain from you will be dealt with in a manner that ensures you remain anonymous. Data will be stored in a secured location at Bond University for a period of 5 years in accordance with the guidelines set out by the Bond University Human Research Ethics Committee.

It is anticipated that the data collected during this study will assist us in better understanding how and why physiotherapists believe exercise to be effective for managing shoulder pain. Your participation in this study will enhance work towards advancing knowledge of exercise mechanisms for shoulder pain, which might lead to more appropriate exercise prescription and improved clinical outcomes.

Should you have any complaints concerning the manner in which this research is being conducted please make contact with –

Bond University Human Research Ethics
Committee, Bond University Office of Research
Services.

Bond University, Gold Coast, 4229, Australia

Tel: +61 7 5595 4194 Fax: +61 7 5595 1120 email:

ethics@bond.edu.au

We thank you for taking the time to assist us with this research. Should you have any questions concerning this research, please contact Jared Powell at jared.powell@student.bond.edu.au

Consent I have read the Explanatory Statement above, I am eligible to participate according to the criteria above and I consent to participate in the investigation into mechanisms of exercise for shoulder pain, conducted at Bond University, and for my data to be used in any publications arising from this research.

- ☐ Yes, I consent (1)
- ☐ No, I do not consent (2)

Q1 What is your age?

Q2 What is your gender?

- ☐ Male (1)
 - ☐ Female (2)
 - ☐ Non-binary / third gender (3)
 - ☐ Prefer not to say (4)
-

Q3 How long have you been registered as a physiotherapist/physical therapist?

- ☐ Less than 5 years (1)
 - ☐ 5-10 years (2)
 - ☐ 10-15 years (3)
 - ☐ 15-20 years (4)
 - ☐ More than 20 years (5)
-

Q4 From which country do you currently (or mainly) practice physiotherapy/physical therapy?
(please write full name of country)

Q5 How many people with shoulder pain do you see in an average week?

- ☐ Less than 5 (1)
 - ☐ 5-10 (2)
 - ☐ 11-15 (3)
 - ☐ More than 15 (4)
-

Q6 Which of the below best describes your work setting?

- ☐ Private practice (1)
 - ☐ Hospital inpatients (2)
 - ☐ Hospital outpatients (3)
 - ☐ Aged care facility (4)
 - ☐ Community health (including home visits) (5)
 - ☐ Professional sport (6)
-

Q7 Do you have a special interest in musculoskeletal shoulder conditions?

- ☐ No (1)
 - ☐ Yes (2)
-



Clinical scenario

A 52-year-old man presents to you with a 6-month history of non-traumatic, gradual onset, right-sided shoulder pain. The man works as a financial planner and thus is not engaged in labour intensive work. The pain is predominately confined to the anterolateral region of the shoulder. There are no radiculopathy symptoms or referral of pain down the arm or up the neck. Pain intensity is mild to moderate in nature, rising to 5/10 at worst and is negligible at rest. Pain type is typically dull unless aggravated, in which the pain can become sharper. Aggravating factors are shoulder abduction (painful arc sign), reaching behind the back and sleeping on the affected side. There is no history of shoulder dislocation or feelings of instability. Passive range of motion (ROM) of the shoulder is preserved. Shoulder external rotation strength, as measured by a hand-held dynamometer, is reduced by 20% on the affected side versus the unaffected side but a massive full thickness rotator cuff tear is not suspected. Cervical spine ROM is full and pain free. The acromioclavicular joint is unremarkable. An ultrasound scan of the affected shoulder has been performed, which reveals tendinopathy of the supraspinatus and thickening of the subacromial

bursa. There are no relevant co-morbidities. The pain is impacting the man's quality of life, mainly disrupting sleep and the ability to participate in his weekly tennis match.

☐ Please make sure you read the above clinical scenario before moving to the next questions. Check this box when you are ready to proceed. (1)

Q8 With reference to the clinical scenario, would you prescribe some form of exercise for this clinical presentation?

☐ Yes (1)

☐ No (2)

Q9 What type of exercise would you *primarily* recommend in this situation? (Select one)

☐ Motor control exercise (including exercise to optimise scapula movement, humeral head position, and the timing of shoulder muscle activity) (2)

☐ Stretching exercise (of surrounding shoulder muscles or shoulder capsule) (3)

☐ Postural exercise (4)

☐ Resistance exercise (1)

☐ Aerobic exercise (7)

☐ Mobility exercise (of the glenohumeral joint, scapula, or thoracic spine) (5)

☐ Proprioceptive exercise (6)

☐ Other, please specify (8) _____



Q10 With reference to the clinical scenario '**how and why**' would you expect exercise to improve shoulder pain and function? (Can select multiple)

☐

Neuromuscular factors (for example: strength, scapular kinematics, posture, range of motion, muscle timing and activity, acromiohumeral distance etc.). (1)

☐

Psychosocial factors (for example: pain self-efficacy, pain catastrophising, kinesiophobia, graded exposure, mood, optimism, depression, anxiety, a sense of belonging etc.). (2)

☐

Tissue healing factors (for example: increased tissue blood flow, tissue remodelling, tissue capacity, tissue homeostasis etc.) (3)

☐

Neurophysiological factors (for example: decreased inflammation, reduced peripheral and central nervous system sensitivity, gate control, pain inhibition, hypoalgesia etc.). (4)

☐

Other (please specify) (5)

Q11 With reference to the clinical scenario, '**how and why**' do you think exercise would *primarily* lead to reduced shoulder pain or increased shoulder function? (Select one)

☐

Biological factors (physical factors) (such as increasing shoulder strength, promoting tissue healing, reducing inflammation etc.) (1)

☐

Psychosocial factors (such as reduced fear of movement, increase pain self-efficacy, decreased anxiety etc.) (2)



Q12 Which *neuromuscular factors* do you think would ***most often*** explain the clinical improvement in shoulder pain and function with exercise? (Can select multiple)

- ☐ Increased shoulder muscle strength (1)
 - ☐ Increased shoulder muscle endurance (2)
 - ☐ Improved shoulder and scapular motor control (3)
 - ☐ Increased shoulder range of motion (4)
 - ☐ Increased thoracic mobility (5)
 - ☐ Improved upper body posture (6)
 - ☐ Increased muscle and soft tissue length (for example pectoralis minor and posterior shoulder capsule) (7)
 - ☐ Increased acromiohumeral distance (8)
 - ☐ Other (please specify) (9)
-
- ☐ None (10)

Q13 With reference to the clinical scenario, do you think *psychosocial factors* would be an ***important mechanism*** underpinning the effectiveness of exercise?

- ☐ Yes (1)
- ☐ No (2)

Q14 What psychological factors do you think exercise would ***most often influence***? (Can select multiple)

- ☐ Pain self-efficacy (1)
 - ☐ Kinesiophobia (fear of movement) (2)
 - ☐ Depression (3)
 - ☐ Anxiety (4)
 - ☐ Confidence (5)
 - ☐ Motivation (6)
 - ☐ Fear avoidance beliefs (7)
 - ☐ Pain catastrophising (8)
 - ☐ Perceived disability (11)
 - ☐ Expectations of recovery (12)
 - ☐ Other (please specify) (10)
-

Q15 With reference to the clinical scenario, do you think ***tissue remodelling/healing*** would be an ***important mechanism*** underpinning the benefit of exercise?

- ☐ Yes (1)
 - ☐ No (2)
-

Q16 With reference to the clinical scenario, do you think **neurophysiological factors** (such as reduced local inflammation and exercise-induced hypoalgesia) would be an **important mechanism** underpinning the benefit of exercise?

☐ Yes (1)

☐ No (2)

Q17 With reference to the clinical scenario, if you identified a scapula dyskinesis in your physical examination, would you expect this to **improve in parallel with shoulder pain and function**?

☐ Yes (1)

☐ No (2)

Q18 With reference to the clinical scenario, would you identify **shoulder external rotation weakness** as a primary treatment target?

☐ Yes (1)

☐ No (2)

Q19 With reference to the clinical scenario, would you attempt to rectify any **same-side postural abnormalities** of the shoulder complex (including thoracic spine, scapula and muscle imbalances)?

☐ Yes (1)

☐ No (2)

Q20 Do you ***regularly measure shoulder strength*** in your clinical practice for people with shoulder pain?

☐ Yes (1)

☐ No (2)

Q21 How do you usually ***measure maximal shoulder strength (force output)*** in your clinical practice?

☐ Manual muscle testing (1)

☐ Hand held dynamometry (2)

☐ Isokinetic testing (3)

☐ Other (5) _____

Q22 With reference to the clinical scenario, what ***diagnostic label*** would you ascribe to this clinical presentation?

☐ Subacromial/shoulder impingement syndrome (1)

☐ Rotator cuff tendinopathy (2)

☐ Rotator cuff-related shoulder pain (3)

☐ Subacromial pain syndrome (4)

☐ Rotator cuff syndrome (5)

☐ Non-specific shoulder pain (6)

☐ Bursitis (9)

☐ Rotator cuff disease (7)

☐ Other (please specify) (8) _____

Q23 If you had *more knowledge* on the possible mechanisms of exercise for *musculoskeletal shoulder pain*, do you think this would *benefit* your clinical practice?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Unsure (3)

“Restoring That Faith in My Shoulder”: A Qualitative Investigation of How and Why Exercise Therapy Influenced the Clinical Outcomes of Individuals With Rotator Cuff–Related Shoulder Pain

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Abstract

Objective. Rotator cuff–related shoulder pain (RCRSP) is the most common form of shoulder pain. Exercise therapy is a first-line recommended treatment for RCRSP. However, the causal mechanisms underpinning the benefits of exercise for RCRSP are not well understood. Moreover, how individuals with lived experience of RCRSP believe exercise helped or did not help them is unknown. This study aimed to gain insights into how individuals with RCRSP believe exercise influenced their shoulder pain and identify the clinical conditions that promoted or inhibited their beliefs.

Methods. This qualitative study was underpinned by a critical realist approach to thematic analysis. Participants were recruited using hybrid purposive and convenience sampling techniques. Each participant attended an online semi-structured interview. The data were coded by 2 members of the research team (J.K.P. and N.C.) and verified by a third (B.S.). Recruitment continued until theoretical sufficiency was achieved. Participants reviewed and validated preliminary causal explanations.

Results. Three causal explanations were consistently expressed by 11 participants to explain the benefits of exercise therapy: (1) shoulder strength; (2) changes to psychoemotional status; and (3) exercise has widespread health effects. However, the activation of these causal mechanisms depended on (1) the presence of a strong therapeutic relationship; (2) the provision of a structured and tailored exercise program; and (3) experiencing timely clinical progress.

Conclusion. Participants believed exercise improved their shoulder pain through associated health benefits, improved shoulder strength, and psychoemotional variables. Whether an exercise program was able to cause a clinical improvement for an individual with RCRSP was contingent on clinical contextual features. Thus, the clinical context that an exercise program is delivered within may be just as important as the exercise program itself.

Impact. Exercise is a recommended first-line intervention to manage RCRSP. The results of this study suggest that a positive experience and outcome with exercise for RCRSP is contingent on several clinical contextual features, such as a strong therapeutic relationship. The clinical context that an exercise program is prescribed and delivered within should be considered by clinicians.

Keywords: Exercise, Rotator Cuff, Shoulder, Shoulder Pain, Subacromial Impingement Syndrome

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Introduction

Shoulder pain is a common and often disabling musculoskeletal pain condition.^{1,2} In those afflicted, it impacts activities of daily living, sleep, physical and emotional function, and participation in valued activities.^{2,3} Rotator cuff–related shoulder pain (RCRSP) is a clinical term introduced in 2016,⁴ and it structurally refers to the muscles, tendons, and surrounding structures, such as bursae, bone, ligament, capsule, nerve, and their concomitant vascular tissues. RCRSP is the most common musculoskeletal shoulder condition and presents as shoulder pain and weakness, most commonly during shoulder elevation and external rotation.^{1,4} RCRSP was introduced to avoid problematic pathoanatomical diagnoses such as subacromial impingement syndrome and non-traumatic rotator cuff tears. Internationally, the term RCRSP is preferred over subacromial pain syndrome,⁵ which refers to an anatomical location that is difficult to comprehend.

Both exercise therapy and education are recommended as the principal non-surgical approach for managing RCRSP.⁶ This is reflected in evidence-based clinical practice guidelines, where exercise therapy is the only treatment featured in all hitherto guidelines for RCRSP.^{7,8} Exercise therapy results in comparable outcomes to more invasive treatment options, such as rotator cuff repair⁹ and subacromial decompression surgery,¹⁰ corticosteroid,¹¹ and platelet-rich plasma injections.¹² However, it must be acknowledged that exercise is far from a panacea for RCRSP.¹³ Ultimately, it is the clinician and patient, together in partnership, who are tasked with devising an agreed treatment plan, which may include an exercise program.

There exists modest evidential support for exercise therapy to manage RCRSP^{14–16}; however, despite a high volume of research testing various combinations of exercise programs, the causal mechanisms underpinning the effect of exercise are largely unknown. Moreover, the clinical conditions (context) that promote or inhibit possible causal mechanisms have received inadequate attention.

Previous qualitative research endeavors exploring RCRSP have focused on the impact of diagnostic labels,¹⁷ patient beliefs about the cause of their shoulder pain,¹⁸ general experiences with exercise,^{19,20} barriers and enablers to exercise,²¹ and the biopsychosocial impact of living with RCRSP.²² An in-depth exploration of the causal explanations expressed by individuals with lived experience of RCRSP about how exercise may have helped them, or not, is missing. Furthermore, knowledge is lacking about the clinical conditions that could trigger or hinder the activation of said causal mechanisms. Acquiring first-person perspectives about causal explanations of exercise may help clinicians understand how an individual with RCRSP might comprehend the utility of an exercise program and identify the clinical conditions that could maximize the benefits of an exercise regimen. Commonly proposed causal explanations could subsequently be tested in quantitative research, using mediation analysis, for example. As such, this study aimed to gain insights into how individuals with RCRSP believed exercise helped their shoulder pain and identify the clinical conditions that promoted or inhibited this.

Methods

Design

A qualitative study using in-depth semi-structured interviews conducted in accordance with the Standards for Reporting Qualitative Research.²³

Qualitative Approach and Research Paradigm

This qualitative research investigation was underpinned by a critical realist philosophy.²⁴ Critical realism is a philosophy of science that integrates a realist ontology, which posits there is something real in the world to find out about, with a relativist epistemology, which is based on the premise that individuals will come to know different things in different ways.^{25,26} Using a critical realist approach to thematic analysis is thought necessary when the primary research question seeks a causal explanation to a particular event or experience.²⁷ The purpose of a critical realist approach to thematic analysis is to produce the most plausible explanations of the mechanisms that cause events or experiences. A critical realist approach to thematic analysis follows a 5-step process, where it is possible, and encouraged, to move freely back and forth between the steps.²⁷ These steps are explicated in detail in the following sections.

Researcher Characteristics and Reflexivity

Lead investigator (J.K.P.) is an Australian trained physical therapist and PhD candidate with 12 years of clinical experience, who has a particular interest in the assessment and management of musculoskeletal shoulder disorders and who has received training in qualitative research. N.C. is a musculoskeletal researcher who has a PhD in physical therapy and draws from both social science and public health lenses when conducting qualitative research. Fellow investigators (B.S., W.H., and J.L.) are experienced researchers and musculoskeletal clinicians with extensive experience in both quantitative and qualitative research methods, each with more than 100 scientific publications. We recognize that the results presented here are informed by our multiple and varied positionalities.

Data Collection Methods

The lead investigator (J.K.P.) conducted 7/11 interviews and N.C. conducted 4/11 interviews. All but 1 interview was conducted via Zoom video conferencing software. The remaining interview was conducted over the telephone using audio recording only as the participant did not like using Zoom. Investigators and participants engaged in the interviews predominantly from a home setting, and on some occasions from their work setting. In all cases, interviews were conducted 1 to 1 with a single investigator. Video and audio interviews were chosen to limit the constraints of geographic location and because this is often the preferred method of participants.²⁸ Data collection commenced on August 2, 2022 and ended on December 5, 2022.

Sampling Strategy

Participants were eligible to participate in this study if they met the selection criteria outlined in Table 1.

Convenience sampling was used to recruit participants via the social media platforms Instagram, Facebook, and Twitter, and who presented to the lead investigators (J.K.P.) clinical practice. As some participants were known to the principal investigator as former patients, a co-investigator (N.C.) interviewed them. Purposive sampling was used to facilitate an even representation of sex and diversity in terms of duration of pain and occupation. As a research group, we acknowledge the ongoing debate regarding when to stop recruitment, as problems have been identified with the traditional “thematic saturation” concept.^{29,30} We opted for theoretical sufficiency as an alternative approach to ceasing data collection. Such an

Table 1. Selection Criteria

Inclusion Criteria	Exclusion Criteria
Aged 18 and above Has had an episode of shoulder pain lasting more than 1 mo Has been assessed by a registered health care professional and been given a diagnosis of rotator cuff–related shoulder pain, which includes rotator cuff tear (full or partial thickness), rotator cuff tendonitis/tendinopathy/tendinosis, shoulder impingement syndrome, and subacromial bursitis Has engaged with a rehabilitative exercise program as prescribed by a registered health care professional Has proficiency in written and spoken English	Had previous shoulder surgery on the affected arm within 12 mo of diagnosis of rotator cuff–related shoulder pain Has a known inflammatory disorder (such as rheumatoid arthritis) Had a fracture on the affected arm within 12 mo of diagnosis of rotator cuff–related shoulder pain Had been diagnosed with frozen shoulder within 12 mo of diagnosis of rotator cuff–related shoulder pain Had known glenohumeral joint osteoarthritis at the time of diagnosis of rotator cuff–related shoulder pain Had displayed evidence of calcific tendinopathy within 12 mo of diagnosis of rotator cuff–related shoulder pain Had a history of shoulder dislocations or subluxations on the affected shoulder Had displayed signs and symptoms of cervicogenic shoulder pain and cervical radiculopathy within 12 mo of diagnosis of rotator cuff–related shoulder pain Had any condition of the arm/shoulder/nervous system that restricts being able to exercise it

approach emphasizes how meaningful the data appears, with the view that if it adds no new perspectives and understandings to the topic explored, it is reasonable to infer that an appropriate sample size has been achieved.^{30,31}

Ethics

Ethical approval for this research project (project number JP03070) was obtained by the Bond University Human Research Ethics Committee. All participants provided written informed consent prior to interview.

Pilot Interview

A pilot interview was recorded with an individual with a history of RCRSP, which lasted for 29 minutes. The pilot interview led to the refinement of language and structure of questions in the interview guide.

Data Processing and Analysis

The interview audio files were transcribed verbatim using the digital platform Rev. Transcripts (Austin, TX, USA) were checked for accuracy against the original audio file, anonymized using pseudonyms and deidentified of relevant geographical locations, and subsequently uploaded to the electronic data management software, NVivo (Denver, CO, USA), for commencement of data analysis. For data analysis, we followed the 5-step critical realist approach to thematic analysis as described by Fryer.²⁷ Investigators J.K.P. and N.C. independently read the first 3 transcripts with the research question in mind, and then met to develop preliminary codes. N.C. then coded 3 of the transcripts and J.K.P. coded 8. J.K.P. developed the causal explanations captured in our codes,²⁷ which were discussed with the research team. The development of causal explanations employs retroductive reasoning, which allows for inferences to be made about what best explains a particular event or experience.²⁵

Techniques to Enhance Trustworthiness

We took several steps to enhance the trustworthiness and rigor of this qualitative research investigation. First, we had

multiple interviewers (J.K.P. and N.C.) and coders (J.K.P. and N.C.). We then had an additional investigator (B.S.) review and verify these codes against the original transcripts. One investigator (J.K.P.) developed and refined the causal explanations in constant consultation with the research team. To enhance the credibility of data analysis and participant involvement, refined causal explanations were sent to study participants for an opportunity to provide feedback or request a modification.^{30,32}

Results

Twenty participants volunteered for this study, with 9 participants unable to meet the selection criteria (8 did not fulfill the clinical presentation of RCRSP, and 1 did not perform an exercise program). Eleven participants with RCRSP with a mean age of 36.5 years and median symptom duration of 16 months were enrolled in the study. The participants were from Australia (7), Canada (1), the United States (1), Germany (1), and South Africa (1). Further participant details are provided in Table 2. The average interview duration was 37 minutes (range 27–45 minutes). A decision was made to cease data collection when the final 3 interviews did not modify existing coding categories (theoretical sufficiency), and the data hitherto obtained were rich in depth and judged to add no new perspectives to the topic investigated. All participants were given the opportunity to review preliminary findings. Participants were satisfied that their individual experiences and perspectives were captured in the results of this study. Overall, exercise therapy was perceived to be a beneficial treatment for RCRSP, under certain conditions:

Condition 1: A Strong Therapeutic Relationship Is the Foundation for a Clinical Improvement With Exercise Therapy

All participants stressed their relationship with their treating clinician played an important role in their engagement in, and improvement through, exercise (Tab. 3). Based on

Table 2. Participant Information

Participant (Pseudonym) Sex, Age (y)	Occupation	Nationality	Duration of Symptoms	Diagnosis	Health Care Professional Consulted	Treatments Trialed	Imaging Received
Luke Male, 32	Maintenance professional	Australian	10 mo (ongoing)	Rotator cuff tendinopathy, subacromial bursitis, and shoulder impingement syndrome	General Practitioner Physical therapist	Rest and exercise-based rehabilitation	X-ray and ultrasound
Kevin Male, 31	Business owner	Australian	18 mo (ongoing)	Partial thickness rotator cuff tear and subacromial bursitis	Physical therapist	Rest, dry needling, and exercise-based rehabilitation	MRI
Claire Female, 36	School teacher	Australian	60 mo (ongoing)	Rotator cuff tendinopathy, partial thickness tear and subacromial bursitis	Osteopathy General Practitioner Physical therapist	Massage, dry needling, rest, ice, and heat pack, NSAIDs, and exercise-based rehabilitation	X-ray and ultrasound
Bill Male, 31	Electrical engineer	Australian	36 mo (recovered)	Shoulder impingement syndrome and subacromial bursitis	General Practitioner Physical therapist Massage therapist Chiropractor Exercise physiologist	NSAIDs, massage, dry needling, chiropractic adjustments, and exercise-based rehabilitation	X-ray, ultrasound, and MRI
Max Male, 52	General manager	Australian	9 mo (ongoing)	Rotator cuff tear and subacromial bursitis	General Practitioner Physical therapist Osteopath	Ice, massage, and exercise-based rehabilitation	X-ray and ultrasound
Jessica Female, 25	Student	South African	16 mo (ongoing)	Rotator cuff tendinopathy and subacromial bursitis	Orthopedic surgeon Physical therapist Biokineticist	Manual therapy, exercise-based rehabilitation, and NSAIDs	MRI
Matthew Male, 33	Strength and conditioning coach	Australian	24 mo (recovered)	Shoulder impingement syndrome	Physical therapist Chiropractor Exercise physiologist	Manual therapy, dry needling, chiropractic adjustments, and exercise-based rehabilitation	None
Ella Female, 65	Retired	American	5 mo (ongoing)	Shoulder impingement syndrome	Physician assistant Physical therapist	Exercise-based rehabilitation	X-ray
Charlotte Female, 26	Student	Canadian	132 mo (ongoing)	Rotator cuff tendinopathy	Physical therapist Massage therapist Chiropractor	Manual therapy, chiropractic adjustments, therapeutic ultrasound, and exercise-based rehabilitation	None
Lisa Female, 34	Nurse	Australian	6 mo (recovered)	Rotator cuff tear and subacromial bursitis	Orthopedic surgeon Physical therapist	Ice, analgesics, manual therapy, and exercise-based rehabilitation	MRI and ultrasound
John Male, 27	Personal trainer	German	4 mo (ongoing)	Subacromial bursitis and rotator cuff tear	Sports physician General Practitioner Physical therapist	Exercise-based rehabilitation, percussive therapy, cupping, massage therapy, NSAIDs, and topical heat cream	X-ray and ultrasound

participants' responses, a strong therapeutic relationship built on trust, collaboration, reassurance, and empathy seemed to be the foundations for a positive experience with exercise. Conversely, a clinical interaction devoid of a strong therapeutic relationship, primarily because of poor communication

or a lack of trust, meant that exercise could not contribute to clinical improvement in shoulder pain or function, either because the patient would seek a different therapist or would not do the exercises. Our interpretation from participants' experiences is that the relational aspects of musculoskeletal

health care can influence whether an exercise program is able to generate a positive clinical outcome (such as reduced shoulder pain) and highlights the importance of the patient-clinician relationship. Thus, we propose that the causal power of an exercise program to positively influence shoulder symptoms is conditional upon a strong therapeutic relationship between the clinician and patient.

Condition 2: The Exercise Program Should Be Structured and Tailored to the Individual Clinical Presentation

Participants often believed that receiving an exercise program that was tailored to their individual clinical presentation was necessary for their clinical improvement (Tab. 3). Some participants expressed dissatisfaction and skepticism when provided with a seemingly generic exercise program that was not believed to be fit for their purpose. This subsequently affected their engagement and belief in the exercise program, which may have impacted on their clinical outcomes.

Participants frequently reported that an exercise program that was carefully planned and had a logical structure was important to them. Having a plan and structure enabled participants to imagine their possible trajectory over time and gave them something real and tangible they could regularly engage with. This created a feeling of accountability for some participants and may have incentivized continued engagement with the exercise program. When an individualized exercise plan was lacking, this resulted in a feeling of being “left alone.” Based on participants’ responses, an exercise program that is structured and tailored to the individual is an important precondition for exercise to be beneficial for individuals with RCRSP.

Condition 3: Timely Clinical Progress With Exercise Therapy Matters

The concept of experiencing “timely progress” was an important feature of exercise therapy for most of the participants (Tab. 3). Experiencing timely progress often reinforced to participants that the exercises they were doing were beneficial, thus incentivizing continued adherence to the exercise program. What constituted progress was varied, but most often it included references to increased shoulder strength (eg, lifting more weight or doing more repetitions of the same weight), pain reduction, improved shoulder range of motion (ROM), and the ability to engage with valued recreational pursuits, such as surfing and pickleball. One participant expressed that although they were happy with gaining shoulder ROM and strength, and experiencing less pain, their ultimate goal was to return to pickleball. Progress in psychoemotional states, such as confidence, was also mentioned. Any obvious improvement in physical measures of the shoulder, feelings of confidence using the shoulder, or the ability to perform a certain physical recreational activity were important metrics that participants used to gauge their progress. When no discernible progress was experienced, doubt and apathy about the particular exercise program ensued. Thus, if an exercise program failed to elicit a demonstrable change in participant signs and symptoms in a timely fashion, this affected the causal power of the exercise program.

The presence of a strong therapeutic relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress were the clinical

conditions that promoted positive experiences and outcomes with an exercise program. From the participants’ experiences, we were able to generate 3 causal explanations for the positive clinical outcomes:

Causal Explanation 1: Shoulder Strength Influences Clinical Outcomes

Most participants reported that increasing shoulder strength or engaging in strengthening exercise was a decisive factor for their positive experience and improvement with exercise therapy (Tab. 4). Some participants reported that they enjoyed the feeling of becoming stronger despite using light weights, while others expressed feeling frustrated when an exercise program was not perceived to be challenging enough. On occasions when a strengthening program was not provided by the treating clinician, this was met with skepticism and doubt. Meanwhile, other participants expressed surprise that their treating clinician encouraged them to try a strengthening-based exercise program and that it was able to produce an improvement in symptoms. There was a belief from some participants that a stretching-based exercise approach or a form of manual therapy was needed for their RCRSP, in part based on past experiences with health care professionals and doing their own research. However, the surprise was often well met by participants, particularly if the treating clinician was able to appropriately explain why they were recommending the said treatment approach.

Some participants also expressed that continuing to engage in shoulder strengthening exercise was important for optimizing long-term shoulder health and the prevention of shoulder pain flare ups. One participant reflected on their journey of getting stronger and progressing with their exercise program, but without an associated improvement in pain. This participant felt reassured by their strength gains and simultaneously disappointed that this development of shoulder strength did not eradicate their pain. Taken together, shoulder strength was the dominant causal explanation for a positive experience with exercise therapy according to this cohort of individuals with lived experience of RCRSP.

Causal Explanation 2: Exercise Therapy Influences PsychoEmotional Status

Participants frequently articulated that the benefits of exercise were in part due its influence on their thoughts and feelings (Tab. 3). In some instances, exercise helped to build or regain trust in their shoulder and also override beliefs that pain during shoulder exercise means it is damaging for their shoulder. There was a tendency for participants to think that rest was the optimal strategy for managing RCRSP, a belief derived mostly from doing their own research. This strategy of rest would sometimes lead to participants overprotecting their shoulder by avoiding basic shoulder movement and exercise. However, engaging in therapeutic exercise that exposed an individual to a movement or exercise that carried an expectation of pain or vulnerability was helpful to change their beliefs about their shoulder pain and capacity. Some participants reported that exercise helped increase confidence in their shoulder, which was sometimes accompanied by reduced fear of using their affected shoulder. Thus, according to the participants in this study, the benefit of exercise for RCRSP goes beyond its biomechanical effects and influences the psychoemotional status of individuals.

Table 3. Supporting Quotes of Clinical Conditions That Promoted or Inhibited the Success of an Exercise Program for an Individual With Rotator Cuff–Related Shoulder Pain

Condition	Supporting Quotes
Condition 1: A strong therapeutic relationship is the foundation for a clinical improvement with exercise therapy	<i>“I think just with the relationship that I built with my physio and I knew that whatever he said I needed or didn’t need, and I trusted his advice, I trusted his education, and how we, I guess, just had that therapist and patient relationship. It was very, very comforting.”</i> (Charlotte) <i>“So I think that was really good too, because I got a much more trusting relationship [with the therapist], that they were just genuinely more interested in me trying to build long term strength and health rather than a repeat customer to some extent.”</i> (Bill) <i>“The way that it was communicated, it didn’t really fill me with confidence that there was a lot of buy-in to getting me out the other end, and I’d say as quickly as possible, because that my motivation was to get out the other end quickly.”</i> (Max) <i>“I never really liked the physio or the head of physio... He was very dismissive in general with a lot of conditions, especially anything to do with CrossFit. So when I went in and got seen, I didn’t get a lot of, I guess, interest. It was like, ‘Oh, another person with shoulder pain’ ... And that’s when I went to the next physio.”</i> (Matthew) <i>“She could temper it in a positive way by telling me how far I’ve come. ‘That’s normal. You’re working those muscles, that’s normal. It’s got to be sore.’ And so she always normalized everything for me. I’d always get really concerned I was making it worse.”</i>
Condition 2: The exercise program should be structured and tailored to the individual clinical presentation	<i>“And again, it seemed a little like it’s a generic document and stuff like that, so you sort of look at it and think, it’s just the same as lots of other people, whether it’s good or bad.”</i> (Max) <i>“Yeah, it felt like it was a more tailored approach to me about me getting better as opposed to just a cookie cutter; here’s a default program for six to eight weeks that should make you better. Everyone does the same thing approach”</i> (Bill) <i>“He guided me through not only with the exercises and giving me a trajectory, which was fantastic, because I really like planning and structure so what it’s going to look like in a month’s time, what it’s going to look like in two months’ time”</i> (Lisa) <i>“Probably relieved to have a bit of guidance, to have a plan. Because although I haven’t had any success, long term success with any of the treatments I’ve done, but just have a plan and someone to check in with fortnightly or monthly. So I felt like it was good and I’m held accountable”</i> (Claire) <i>“So if something felt too easy, I’m like, Ah, is it of benefit if it feels too easy, or if there’s pain there, is that an issue or not... But at the time, I still felt like I was on my own to figure it out, and he didn’t provide a follow-up appointment or anything. It was more just, ‘Yeah, do this for a couple weeks. Your shoulder will be fine. If it’s not fine, then we can chat later.’ But there was no the check-ins scheduled or anything.”</i> (Kevin)
Condition 3: Timely clinical progress with exercise therapy matters	<i>“Okay, I can see the progress, I can see what’s happening with my shoulder.”</i> (Charlotte) <i>“What really helped absolutely in me not giving up, of course, is seeing progress.”</i> (John) <i>“It’s been four or five weeks, I’m already feeling an improvement in that now, I can demonstrate to you and I don’t have that same twinging, sharp impingement pain. And I put that down to the exercise that I’ve been doing religiously for the last five weeks. So that’s had a better outcome for me than the osteo treatments.”</i> (Claire) <i>“But anyway, I like the exercises even though at first they made me very sore. When I stuck with them I was like, ‘Oh my gosh, I can go further, higher, longer.’ Then we would increase the resistance, we would increase the band resistance, how they have really light ones and they get heavier, so we could increase those.”</i> (Ella) <i>“And then once I started building up [strength], I started getting confidence.”</i> (Lisa) <i>“I had 80% strength when I first saw the physio and did that initial consultation and then probably after three or four months, I probably only had 30 or 40% strength in my shoulder ... So, yeah, that was very frustrating after a while because I was like, oh, I am doing these [exercises] properly. And then it probably got to the point where I was kind of like, well, does it really matter if I don’t do it [exercise] tonight, or if I don’t do it tomorrow, and I found [it] really hard to then motivate myself to stick to that same pattern of programming and exercises.”</i> (Bill) <i>“Even though I’ve seen progress and she’s [clinician] positive and I loved working with her and we had a connection, to me I’m still not back playing pickleball yet. I’m still not back to doing all the things I usually do.”</i>

Causal Explanation 3: Exercise Therapy Has Widespread Positive Health Effects

Exercise was often believed to be an intrinsically good activity to engage with due to its varied positive influence on general health (Tab. 3). Exercise was often thought of as a healthy behavior, like eating a nutritious meal, and having multi-system benefits that go beyond the shoulder. This helped the

perception of exercise therapy as a beneficial and productive treatment. This may also have helped participants continued engagement with exercise, comfortable in the knowledge that even if exercise didn’t help their shoulder pain specifically or substantially, at least they had done something generally positive for their health. The productive nature of exercise and its perceived capacity to have widespread positive health

Table 4. Supporting Quotes of Causal Explanations for a Positive Experience With Exercise Therapy

Causal Explanation	Supporting Quotes
Causal explanation 1: Shoulder strength influences clinical outcomes	"It's great. I could just feel myself getting stronger even though I'm using two kilo[gram] dumbbells. It's really light, but I just love it." (Claire) "And then the second I started strength training, I felt, yeah, just doing one exercise, every part of my shoulder was engaged. I was feeling that instant connection between the exercise I was doing and a positive improvement in my shoulder." (Bill) "And so I felt that that's what I was doing. I felt those exercise bands or exercises were working muscles I hadn't used in a long time properly." (Ella) "So he did the dry needling and then I just grilled in with questions after. I'm like, what's now? Am I going to get a strengthening program, and what are your thoughts, what do you think this is? When can I get back to activities, when can I do this? (Kevin) "I didn't feel like that was actually building any sort of strength or stability in my shoulder. There were exercises that, they were isolating the muscles that they were trying to do, but overall I wasn't building any sort of strength or resistance to an actual weight that I would be using in real life." (Bill) "The strengthening exercises got rid of my pain. It was really bizarre process to me because I thought these sorts of pain things would need stretching, and definitely, I could never lift weights again, and starting to lift weights slowly and doing certain things, like increasing my range in my shoulder with the strength exercises, the pain would just go." (Lisa) "I was not expecting him to be taking me to do dumbbell weights. I thought it was different, but I was open to suggestion because I guess he was really confident about it as well. He's like, 'You're weak, this will help'." (Claire) "So, even as I progressed strength wise, and I could do heavier things, more complicated things, that same pain would just stay throughout the whole progression [of exercise] . . . So, that was sort of a bit of, I felt let down by the universe rather than be let down by the exercise, because I was like, 'I'm doing this exercise, and it's worked so, so well for everything else. Why is it not working for this?'" (Jessica) "So if I had a period where I didn't go to the gym for three or four weeks or something like that, and then something else happened that was generally when I then instantly start to feel that I was susceptible, if you like, to having more of an underlying issue. But as long as I was maintaining that consistent strength training, yeah, I haven't had any issues since with my shoulders, which has been really good." (Bill)
Causal explanation 2: Exercise therapy influences psychoemotional status	"But obviously the exercise was important, like I said, for my mental state, to know that I was still physically capable of doing stuff." (Max) "Just restoring that faith in my shoulder, I suppose, which is what he got me to eventually do with all of the strength exercises." (Lisa) "I went crazy Googling it [bursitis] and it was telling me rest, rest, rest . . . And I think mentally, if the pain is coming from moving my arm, then I would just stop moving my arm and it wouldn't give me as much grief, but it was limiting my ability to do things . . . I hadn't read anything online about going and getting two and three kilo dumbbells to fix a shoulder injury . . . It was almost, it felt good to push through the discomfort [when exercising shoulder], knowing that it was for the best, if that makes any sense. So even though it wouldn't feel the same on both sides, it would feel discomfort and a bit twingey just being told by one person that it's [exercise] actually not going to hurt me, I was happily able to continue it and know that was for the best . . . It was more of a mental thing than it was physical." (Claire) "So I was very nervous at first [doing shoulder exercises], but I mean, he was watching and walking, doing a 360 and, I guess, checking to see how things were moving. And then when I realized that it wasn't shooting pain... I think I just kept saying... I kept saying, 'I can't believe I'm doing this. I never thought I'd be doing this again'. is what I kept saying to him . . . 'Wow, I can't believe it'. It was almost like it was good. It was having a little mini personal training session because I never thought I'd have that range or the ability to do that again." (Claire) "Even though I was doing all the exercises and gaining strength and things, I still didn't trust myself to do bodyweight exercises . . . I thought for some reason it [shoulder] would just buckle, but I had exercises building me up to that plank . . . and then anyway, I eventually got to a plank towards the end, and that's amazing, and look how far I've come." (Lisa) "But yeah, I did that [exercises] for a couple of days and it seemed to just take away that fear of using my shoulder and just give me a little bit more confidence that it was sort of working best again." (Max)
Causal explanation 3: Exercise therapy has widespread positive health effects	"It's a positive. It's beneficial. Feels good [exercise] . . . Obviously exercise is a good thing, if done right. It's good for joints. It's good for muscle. It's good for tendons. It's good for ligaments. It's good for strength. It's good for mental health." (Luke) "They [exercises] always feel good because it feels like I'm eating a healthy meal or doing a sporting activity. It feels like you're doing something to get better . . . So I've always put them as this is something that's good for me, so I get a feeling of achievement at the end of it and I'm doing something good for my body." (Kevin) But obviously the exercise was important, like I said, for my mental state, to know that I was still physically capable of doing stuff. But also obviously using it and moving it is probably good for the muscles and keeping things in as best condition, I guess, they could be in. (Max)

effects were a common causal explanation for a positive experience with exercise.

Discussion

This study aimed to gain insights into how individuals with RCRSP believed exercises helped or didn't help their shoulder pain and identify the clinical conditions that promoted or inhibited this. Whether exercise caused a positive clinical improvement was conditional on certain contextual factors: the presence of a strong therapeutic relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress. If these conditions were partially or fully satisfied, exercise therapy consistently produced an improvement in shoulder pain and function, most commonly via the causal explanations: increase in shoulder strength, a positive change in psychoemotional status, and widespread positive influences of exercise on general health.

Most participants in this study expressed that their relationship with their treating clinician was a key part of their experience of engaging with an exercise program for their shoulder pain. A suboptimal or strained therapeutic relationship often led to a poor experience with exercise and the subsequent pursuit of a different health care professional. Conversely, a strong therapeutic relationship was often the foundation for a positive experience with exercise. Thus, the causal power of an exercise program depended on the relationship and interaction between the clinician and individual seeking care, and the better the relationship, typically the better the experience with exercise. The value of a strong therapeutic relationship across diverse non-traumatic musculoskeletal conditions has been discussed in the literature. People with lived experience of patello-femoral pain (PFP),³³ knee osteoarthritis,³⁴ non-specific low back pain,³⁵ RCRSP,³⁶ and greater trochanteric pain syndrome³⁷ consistently express that a trusting, empathetic, and united relationship between themselves and their treating clinician is an integral component of their care. This seems to extrapolate to clinical outcomes too, with evidence reporting a strong therapeutic relationship is associated with improved clinical outcomes.³⁸ Crucially, a strong therapeutic relationship may facilitate better adherence to a prescribed exercise program.^{39,40} Taken together, we conjecture that even the best exercise program might lack causal power in the absence of a strong therapeutic relationship. Thus, we urge clinicians to take time to build this relationship before rushing to provide their expertly crafted exercise program.

Participants who were dissatisfied with a particular exercise approach often lamented that their exercise program was generic and not tailored to their individual goals and needs. A desire for individualized exercise prescription reported in this study is similar to the previous qualitative research evidence for PFP and non-specific low back pain.^{33,41} The desire for a tailored approach to exercise prescription for RCRSP is supported by empirical data which suggest there is no universal best exercise approach.⁴²⁻⁴⁴ Therefore, rather than decreeing 1 particular exercise approach as superior, clinicians should endeavor to construct an exercise program in close collaboration with the individual in question and with careful consideration of access to equipment, past experiences with exercise, beliefs about exercise, and their individual goals.

Experiencing timely clinical progress with an exercise program was important for most participants. Most of the

time, progress took the form of an improvement in shoulder strength or the experience of less shoulder pain with a particular movement, which aligns with previous qualitative research in the area of non-specific low back pain.⁴¹ Similar to the work of Littlewood et al,²⁰ a lack of timely symptom improvement was met with suspicion and doubt about the benefit of a particular exercise program, which affected motivation and adherence to the exercise program, ultimately leading to poor clinical outcomes. The recovery from RCRSP with exercise is not usually a quick process, and in some cases, it is recommended that 12 months of exercise therapy be trialed prior to escalating treatment to more invasive treatments⁴⁵; the desire for a timely improvement in shoulder symptoms by patients with exercise may prove difficult. Therefore, we encourage clinicians and patients to have open and honest conversations about possible recovery timeframes. Clinicians should consider incentivizing patients to continue with a particular exercise approach by tracking changes in shoulder strength and ROM, using outcome measures that assess ability to perform valued activities (such as the Patient Specific Functional Scale),⁴⁶ and use general patient-reported outcome measures to objectively gauge clinical progress.

The dominant causal explanation of participants in this study for a positive experience with exercise for RCRSP was a perceived improvement in shoulder strength. This finding is concordant with causal explanations proffered by clinical trialists⁴⁷ and practicing physical therapists⁵ for the beneficial effect of exercise for RCRSP. Outside of the shoulder, a similar theme is reported for the effect of exercise for non-specific low back pain⁴⁸ and knee osteoarthritis.⁴⁹ Taken together, the prevailing view of researchers, clinicians, and individuals with lived experience of RCRSP is that "getting stronger" is the key mechanism underpinning the benefits of exercise therapy for RCRSP. This is despite there being no empirical support that shoulder strength is a mediator of outcomes for individuals with RCRSP.⁵⁰ It remains biologically plausible that shoulder strength is causally linked to positive clinical outcomes in people with RCRSP, based on evidence which shows that quadriceps strength mediates improvements in pain and physical function in individuals with knee osteoarthritis.⁵¹ Therefore, the biological plausibility and consistent reports from different stakeholders regarding the importance of shoulder strength means that it is a casual explanation researchers and clinicians should take seriously.^{52,53} Another advantage of using shoulder strength as a useful heuristic to causally explain the effect of exercise for RCRSP is that it is a cogent word that individuals with varying degrees of health literacy can understand. Clinicians should cautiously consider using shoulder strength as a valid and comprehensible causal explanation for the beneficial effect of exercise. Further research is required to strengthen this proposal.

Various psychoemotional states were expressed by participants as being influenced by exercise therapy, including increased confidence and belief in their shoulders, reduced fear of shoulder movement, and reassurance that their painful shoulder was still able to perform basic activities. Kinesiophobia and pain self-efficacy are associated with clinical outcomes in people with shoulder pain⁵⁴⁻⁵⁶; however, it is uncertain to what extent exercise can modify these constructs. Research on osteoarthritis has shown self-efficacy to be a mediator of clinical outcomes⁵⁷ and this could well be the case for RCRSP.⁵⁸ There is also low-quality evidence that exercise training can effectively reduce fear avoidance beliefs

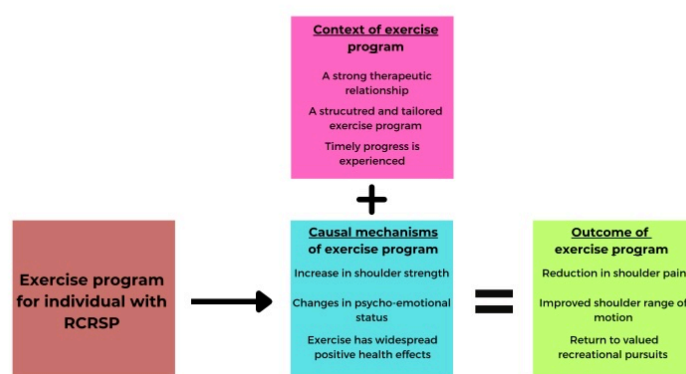


Figure. The relationship between Intervention-Context-Mechanism-Outcome for individuals with rotator cuff-related shoulder pain (RCRSP).

in a predominately spinal pain cohort (cervical and lumbar spine).⁵⁹ Some participants alluded to experiencing a psychological phenomenon with exercise therapy that resembles expectancy violation. Expectancy violation⁶⁰ is a concept embedded within exposure therapy, which has been a mainstay of treatment for anxiety disorders for decades.⁶¹ When applied to musculoskeletal pain, expectancy violation represents the discrepancy between expected and experienced pain during a specific movement or task. It is theorized that a mismatch between expectation and experience is critical for new learning^{61,62} and the updating of possible unhelpful understandings about pain. Some participants in this study expressed surprise that they could lift a dumbbell weight without pain or that they could work up to doing body-weight exercise despite initially not trusting their shoulder. This surprise or “expectancy violation” may have contributed to enhanced feelings of confidence in their shoulders and provided reassurance and motivation that they were on the right pathway to recovery. Based on the experiences of the participants in this study and also the current evidence base, we contend that various psychoemotional states underpin a positive experience with exercise for RCRSP, and clinicians should consider building this into their education.

Participants in this study often acknowledged that exercise can positively influence multiple bodily systems. This sentiment agrees with an abundance of evidence reporting the positive association between exercise and general health and wellbeing.^{63–68} Exercise was often recognized as a fruitful treatment to engage with because of its healthy behavior connotations, which may have led to perceived improvement in shoulder symptoms. Taken together, causal explanations for the benefit of exercise for RCRSP could involve references to the whole-body effects of exercise.

It is important to clarify that the causal mechanisms of exercise that led to a positive clinical outcome in this cohort of individuals with RCRSP were only triggered in the presence of an appropriate clinical context (Figure). That exercise has causal powers which depend on its manifestation partners (individual with RCRSP and clinician) is a novel theory when specifically applied to exercise and RCRSP but fits comfortably within established critical realism philosophy⁶⁹ and dispositionalist theories of causation.^{70–72} If we take this theory to its logical conclusion, there probably is no magical dose or type of exercise that will universally help all individuals

with RCRSP—because every individual will present with their own set of personal dispositions which may or may not respond to a particular exercise program or the prescribing clinician. Any exercise program for RCRSP has the potential to help 1 individual, harm another, or have no effect.⁷³ Person-centered health care acknowledges the medical uniqueness of an individual, and it makes pragmatic and philosophical sense to use exercise therapy with this theory in mind.⁷¹

Limitations

There are methodological considerations to this study which warrant attention. The sample size of 11 participants may be considered small from a quantitative research standpoint. However, it is important to emphasize that this is an original qualitative research investigation, and the sample size was derived by achieving theoretical sufficiency. The lead researcher was a novice interviewer but is an experienced musculoskeletal clinician well versed in communicating with people with shoulder pain, who also undertook training in qualitative research interviewing prior to commencing the study. All interviews were conducted via online video conferencing software, which could have affected researcher-participant rapport, although evidence does support the use of this method of interviewing.²⁸ Furthermore, data were predominately collected from people from economically developed countries whose first language was mostly English. It is important to acknowledge and respect that navigating pain, health care, and exercise for a particular musculoskeletal pain condition is influenced by cultural aspects and thus the findings of this study may not be transferable to other sociocultural contexts. Future research efforts might consider replicating the research methods used in this study and applying to a cohort of individuals from economically developing countries.

Conclusion

In summary, the most common causal explanations for a positive experience with exercise in individuals with RCRSP were an increase in shoulder strength, changes to psychoemotional status, and the belief that exercise has widespread positive health effects. However, these causal mechanisms were only

activated in the clinical context of a strong therapeutic relationship, the provision of a structured and tailored exercise program, and the experience of timely clinical progress. Clinicians should consider not just the exercise parameters of an exercise program but also the clinical context in which the exercises are prescribed.

Authors' Contributions

Jared Powell (Conceptualization [lead], Data curation [lead], Formal analysis [lead], Investigation [lead], Methodology [lead], Project administration [lead], Validation [equal], Writing—original draft [lead], Writing—review & editing [equal]), Nathalia Costa (Conceptualization [supporting], Data curation [supporting], Formal analysis [supporting], Investigation [equal], Methodology [supporting], Project administration [supporting], Supervision [equal], Validation [equal], Writing—review & editing [equal]), Ben Schram (Conceptualization [supporting], Data curation [supporting], Formal analysis [supporting], Investigation [supporting], Methodology [supporting], Validation [equal], Writing—review & editing [equal]), Wayne Hing (Conceptualization [supporting], Methodology [supporting], Project administration [supporting], Supervision [equal], Writing—review & editing [equal]), and Jeremy Lewis (Conceptualization [supporting], Formal analysis [supporting], Methodology [supporting], Supervision [equal], Writing—review & editing [equal])

Ethics Approval

Ethical approval for this research project (JP03070) was obtained by the Bond University Human Research Ethics Committee.

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Data Availability

The data that support the findings of this study are available from the corresponding author, [JKP], upon reasonable request.

Disclosures

J.K. Powell and J. Lewis receive remuneration for the provision of continuing professional development courses on shoulder pain rehabilitation. The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no other conflicts of interest.

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APPENDIX 5: INTERVIEW GUIDE

Hello (insert name). Thanks so much for agreeing to participate in this study. We are interested in knowing more about your experience engaging with exercise because of your shoulder pain. This study aims to gather information about your overall experience – e.g., what it was like for you, difficulties you may have encountered while engaging in exercise, whether you thought it was beneficial or not, and how and why you believe it may or may not have worked. There are no right or wrong answers – we are interested to hear more about your experience, so you are the expert here - the expert by experience.

Please stop me at any time if you need to take a break or want to end the interview for any reason. Also, remember that you don't have to answer every question – just let me know if you want to move on to the next question.

Lastly, I would like to remind you that everything you say during the interview will remain anonymous.

Do you have any questions or want more information?

Before we start, can I please confirm that we have your permission to audio-record this interview and that you agree to take part in this interview?

1. Would you like to start off by telling us your shoulder pain story?

- Prompts:
 - Can you recall how your shoulder pain started?
 - What does/did your shoulder pain feel like?
 - What sort of treatments have you tried?
 - How did exercise compare to these other treatments?
 - Can you describe the context of the exercises you were asked to perform?
 - Were they at home, 1-1 with the therapist, in a group class, performed with family members etc.

2. Now I would like to ask you to take a few minutes to reflect about the exercises you have tried because of your shoulder pain. It might be hard to remember them all so feel free to take some notes and share one by one with me. Can you remember what type of exercise(s) you performed?

Follow up questions:

- What was it like for you to do exercise __ (fill the blank with what they say) ____?
- Do you think these exercises had an impact on your shoulder pain? (positive or negative)
 - How and why?
- Can you recall what sort of thoughts you had when you were doing the exercises?
 - (Clarifying question: It sounds like you (e.g., enjoyed, didn't like) doing the exercises. Is that a fair interpretation what you just said? Why do you think you enjoyed/didn't enjoy it?)?
- Can you remember how doing the exercises made you feel in regards to your shoulder pain?
- Did this impact on your engagement with the exercise? For instance, how often you did it, how long you did it for? If so, how?
- Can you describe the context of the exercises you were asked to perform?

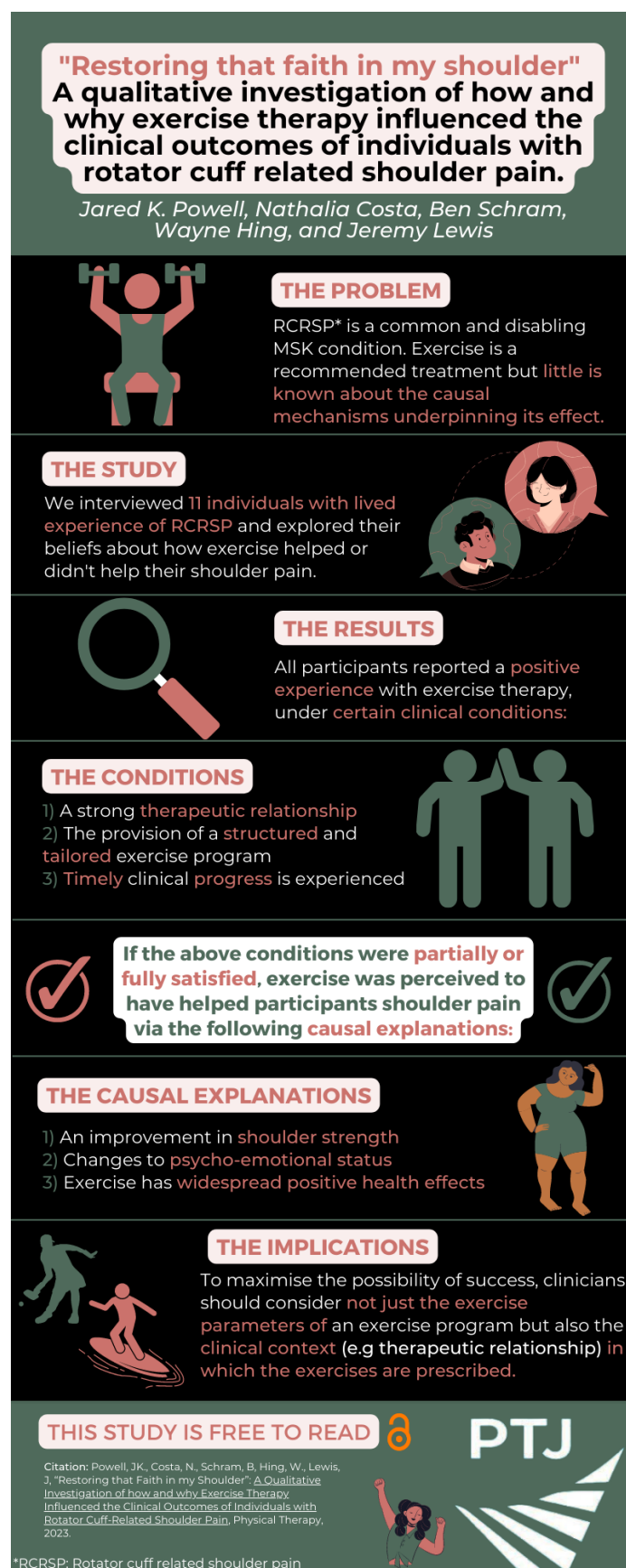
- Were they at home, 1-1 with the therapist, in a group class, performed with family members etc.

3. Now I want you to try to recall what your therapist told you when they suggested the exercises to you. What did your therapist say to you about ‘how or why’ exercise might help you?

Follow up questions:

- If the patient can’t answer: how did the therapist say that exercise might influence their shoulder pain?
 - Did the therapist’s explanation make sense to you? Did this align with your perception? Why or why not?
 - Is there anything you would have liked the therapist/s to have done differently?
- 4. You mentioned in your information form that you received [insert imaging type here] for you shoulder pain. Did this influence you at all with your exercises?**
 - 5. Would you consider exercise if you happen to develop shoulder pain again? Why or why not?**
 - 6. Is there anything else you would like to mention, or do you think it is important for me to know?**

APPENDIX 6: INFOGRAPHIC FOR QUALITATIVE STUDY



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REVIEW ARTICLE

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Is exercise therapy the *right* treatment for rotator cuff-related shoulder pain? Uncertainties, theory, and practice

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Abstract

Background: Exercise therapy is a popular non-surgical treatment to help manage individuals with rotator cuff-related shoulder pain (RCRSP) and is recommended in all clinical practice guidelines. Due to modest effect sizes, low quality evidence, uncertainty relating to efficacy, and mechanism(s) of benefit, exercise as a therapeutic intervention has been the subject of increasing scrutiny.

Aims: The aim of this critical review is to lay out where the purported uncertainties of exercise for RCRSP exist by exploring the relevant quantitative and qualitative literature. We conclude by offering theoretical and practical considerations to help reduce the uncertainty of delivering exercise therapy in a clinical environment.

Results and Discussion: Uncertainty underpins much of the theory and practice of delivering exercise therapy for individuals with RCRSP. Nonetheless, exercise is an often-valued treatment by individuals with RCRSP, when provided within an appropriate clinical context. We encourage clinicians to use a shared decision-making paradigm and embrace a pluralistic model when prescribing therapeutic exercise. This may take the form of using exercise experiments to trial different exercise approaches, adjusting, and adapting the exercise type, load, and context based on the individual's symptom irritability, preferences, and goals.

Conclusion: We contend that providing exercise therapy should remain a principal treatment option for helping individuals with RCRSP. Limitations notwithstanding, exercise therapy is relatively low cost, accessible, and often valued by individuals with RCRSP. The uncertainty surrounding exercise therapy requires ongoing research and emphasis could be directed towards investigating causal mechanisms to better understand how exercise may benefit an individual with RCRSP.

KEYWORDS

exercise, movement, pain, physiotherapy, shoulder

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1 | BACKGROUND

Shoulder pain is both common and burdensome (Lucas et al., 2022). While not everyone afflicted suffers to the same extent, evidence from qualitative research reveals the profound impact shoulder pain can have on many dimensions of life (Maxwell et al., 2021; Page et al., 2019). There are myriad causes of shoulder pain, the most common being rotator cuff-related shoulder pain (RCRSP) (Luime et al., 2004). RCRSP is an overarching diagnostic label that includes traditional pathoanatomical diagnoses such as rotator cuff tendinopathy, subacromial bursitis and rotator cuff tears, and can be tentatively posited when shoulder stiffness, instability, and sinister pathology are not suspected to be part of the clinical picture at the time of assessment (Lewis, 2016). A recent study suggested that RCRSP was the preferred diagnostic term of clinicians over subacromial impingement syndrome, subacromial pain syndrome and rotator cuff tendinopathy (Powell et al., 2022a).

Non-surgical management options to reduce the pain and disability associated with RCRSP include education, understanding pain, exercise therapy, life-style management, hands-on therapy, electrical modalities, taping, braces, dry needling, acupuncture, and injection therapy. Often, these are delivered in various combinations with each other. Despite the many treatment options, with approximately equivalent effects, clinical practice guidelines consistently recommend exercise therapy as the main treatment for RCRSP (Doiron-Cadrin et al., 2020; Lafrance et al., 2022).

Exercise and movement therapy are considered an essential component of physiotherapy practice and physiotherapists are justified in making claims of being movement experts (Nicholls & Vieira, 2023). Physiotherapy management of individuals with RCRSP is an apropos example of this, with a recent study highlighting that 99% of surveyed physiotherapists around the world indicating they would use exercise to manage an individual with RCRSP (Powell et al., 2022a). Despite physiotherapists broadly embracing exercise therapy, in both historical and modern contexts, the pre-eminent position of exercise for RCRSP (Dube et al., 2023; Littlewood et al., 2023; Page et al., 2016), and other musculoskeletal conditions such as hip and knee osteoarthritis (Henriksen et al., 2024; Holden et al., 2023; Hunter & Hall, 2023), has come under increasing scrutiny. Critics appropriately assert that exercise does not appear to be held to the same standards as other treatments, such as manual therapy, surgery, and acupuncture, when considering its modest effects and low certainty of evidence (Naunton et al., 2020; Steuri et al., 2017), lack of demonstrated efficacy (Bennell et al., 2010), and importantly uncertainty regarding the causal pathways through which it may confer a therapeutic benefit (Powell et al., 2022b). Moreover, no evidence has emerged to define the best exercise approach (including exercise type, dose, level of supervision, duration etc.) for helping an individual with RCRSP (Littlewood et al., 2015; Malliaras et al., 2020; McConnell et al., 2022). Any combination of exercise that has been investigated for RCRSP, produces on average, modest results.

This uncertainty represents a paradox for clinicians who, on one hand, are often denigrated for incorporating manual therapy into

management, but are consistently advised to prescribe therapeutic exercise, with both interventions, provided in isolation or combination, associated with less-than-optimal outcomes (Pieters et al., 2020). In this critical review, we aim to lay out where the uncertainties of exercise for individuals with RCRSP exist and conclude by offering theoretical and practical considerations to help clinicians navigate the uncertainty of delivering therapeutic exercise in their practice.

2 | EFFICACY AND EFFECTIVENESS

In order to establish the efficacy of a treatment, it is considered necessary to compare the experimental treatment (e.g. exercise) with a sufficiently similar control treatment (typically a sham/placebo treatment) (Hohenschurz-Schmidt et al., 2023). Only one high quality study (Bennell et al., 2010) compared a treatment package of manual therapy and exercise with a sham control (inactive ultrasound) for individuals with RCRSP and reported no significant difference in shoulder pain and disability after 11 weeks. At 22 weeks, the exercise and manual therapy group had a significantly greater improvement in shoulder pain and disability, but the difference was not clinically meaningful. This trial challenges the assumed efficacy of exercise for RCRSP. A criticism of this study is the comparator intervention, and considerable uncertainty exists if a detuned ultrasound machine is a sufficiently similar control for complex treatments such as exercise and manual therapy (Hohenschurz-Schmidt et al., 2023).

Exercise therapy appears to out-perform a no treatment or no exercise control for improving shoulder pain and function; however, the magnitude of this effect is generally modest (Liaghat et al., 2021; Naunton et al., 2020; Steuri et al., 2017) and the certainty of evidence is assessed to be very low to low. A systematic review and meta-analysis reported that progressive resistance exercise compared with no treatment or placebo confers a benefit of uncertain clinical importance for pain and function (Naunton et al., 2020). The same review found that non-progressive and non-resisted exercise confers no benefit over no treatment, or placebo (Naunton et al., 2020). Findings from a systematic review and network meta-analysis concluded that exercise had the most robust evidence of being an effective treatment for RCRSP when compared to other non-surgical treatments (Babatunde et al., 2021).

When compared with more invasive treatment approaches, such as injection and surgery, exercise fares well. For example, there is no clinically important difference between exercise therapy and subacromial decompression surgery and rotator cuff repair surgery (Karjalainen et al., 2019; Lähdeoja et al., 2020). Corticosteroid injections have a similar effect to exercise therapy (Hopewell et al., 2021; Page et al., 2016); however, there is uncertainty pertaining to the possible deleterious effects of corticosteroid injections on local shoulder soft tissue (Dean et al., 2014). Furthermore, exercise therapy out-performs platelet rich plasma injection at short-term follow-up and is equivalent at long-term follow-up (Nejati et al., 2017).

The main finding of a recent randomised control trial (RCT), not included in any of the aforementioned reviews, was that the addition

of a specific motor control or strengthening exercise programme to education did not enhance the clinical outcomes of individuals with RCRSP compared with education alone (Dube et al., 2023). Thus, the view that exercise is necessary for everyone diagnosed with RCRSP is challenged. Overall, exercise therapy demonstrates a modest effect of uncertain clinical importance when compared to a no treatment or no exercise control, has no evidence of being superior to a realistic sham treatment, and for many, doesn't out-perform an education programme. Exercise has comparable effects to shoulder surgery, and injections, and has the most robust evidence of effectiveness of common non-surgical treatment options.

3 | SHOULD EXERCISE BE DELIVERED IN ISOLATION OR COMBINED WITH MANUAL THERAPY?

In an update of systematic reviews (Pieters et al., 2020) made 'strong' recommendations for exercise therapy as the first-line of treatment to help manage signs and symptoms of RCRSP. A strong recommendation was also made to combine exercise therapy with manual therapy in the short term. A more recent systematic review and meta-analysis reported no significant difference between exercise in isolation compared with exercise plus manual therapy at both short and long term follow ups for both shoulder pain and function (Paraskevopoulos et al., 2023). Since the publication of these reviews, an RCT has been published by Michener et al. (2024) reporting there is an added long-term benefit to providing manual therapy in conjunction with an exercise programme compared to an exercise programme alone. It is unclear the mechanism underpinning the possible added benefit of manual therapy to an exercise programme, as highlighted by another recent RCT which reported no between group differences between sham manual therapy and real manual therapy, when added to an exercise programme (Naranjo-Cinto et al., 2022). Thus, one could speculate that any added benefit of manual therapy might be due to contextual effects. Based on current evidence, exercise could be delivered either in isolation or in conjunction with other therapies, such as manual therapy, and this will depend on shared decision making (Hoffmann et al., 2020).

4 | IS THERE AN OPTIMAL EXERCISE APPROACH?

The history of medicine has never been a particularly attractive subject in medical education...virtually anything that could be thought up for the treatment of disease was tried and, once tried, lasted decades or even centuries before being given up.

(Thomas, 1977)

The history of physiotherapy is punctuated with the rise, fall, and stagnation of various exercise approaches for managing musculoskeletal pain. Hypotheses exist that have been purported to support

stretching, strengthening, movement performance, motor control exercise, breathing and relaxation exercises for managing various musculoskeletal pain conditions, including RCRSP. At this juncture, it is arguably correct to state that there is no one best exercise approach for managing individuals with RCRSP (Littlewood et al., 2015; McConnell et al., 2022).

Here we explore common variables physiotherapists consider when constructing exercise programs for individuals with RCRSP and examine their influence on clinical outcomes.

4.1 | Is there a superior exercise type?

The selection of an exercise type (e.g. resistance exercise, motor control exercise, and stretching exercise) to manage an individual with RCRSP poses a conundrum for clinicians. There are many exercise approaches available to help an individual with RCRSP, and it is typical to see two or more different approaches combined together in the same programme (Powell et al., 2022b). In this review, we focus on two of the most popular exercise approaches for RCRSP: progressive resistance exercise and motor control, or movement facilitation exercise (Powell et al., 2022a, 2022b). Most current meta-analyses report no sustained significant difference between specific motor control exercise and general resistance exercise for RCRSP (Bury et al., 2016; Shire et al., 2017). A recent three-arm RCT not included in the latest meta-analyses corroborates these findings, reporting no significant differences between education alone, education and motor control exercise, and education and resistance exercise in clinical outcome (Dube et al., 2023). Given the apparent equivalence of the two most common exercise types, perhaps it is more useful to consider when a particular exercise approach might be more appropriate for an individual based on their preferences and symptom profile. Under this framework, clinical decisions about exercise type will depend more on the symptom irritability and preferences of an individual, rather than a preconceived bias to favour one exercise approach over another, allowing clinicians to move fluidly between exercise types as the clinical situation dictates (Lewis et al., 2022; McClure, 2015).

4.2 | Does the exercise dose make the poison?

Exercise dose (volume) is described by the load lifted, the number of repetitions, and the number of sets of repetitions (Phillips & Winett, 2010). Malliaras et al. (2020) conducted a systematic review comparing higher vs. lower dose resistance exercise for RCRSP and found low to very low certainty evidence that higher dose resistance exercise confers superior functional outcomes compared to lower dose exercise (Malliaras et al., 2020). It must be noted that this review only included three RCTs in its analysis and was clear in stating that their results did not support the claim that higher dose resistance exercise was better than lower dose resistance exercise. Since the publication of the Malliaras et al. (2020) review, an RCT

exploring exercise dose for RCRSP has been published by Clausen et al. (2021) and reported that adding a large dose of resistance exercise to usual care did not provide any additional benefit for individuals with RCRSP. However, in a pre-defined secondary analysis, Clausen et al. (2023) reported that the level of baseline pain catastrophising modified the effect of the extra dose of resistance exercise (Clausen et al., 2023). Those with lower baseline catastrophising benefited more from an extra dose of resistance exercise, whereas those with higher catastrophising scores actually tended towards an unfavourable outcome. Another recent RCT, not included in the Malliaras et al. (2020) review, similarly reported no significant difference between a progressive higher load resistance exercise regimen and a lower load programme (Schydrowsky et al., 2022). For tendinopathy in general (including studies pertaining to RCRSP), it has been reported that resistance exercise with an external load, compared to body weight only, is more effective (Pavlova et al., 2023), perhaps increasing credence that some external load is better than none.

Uncertainty surrounds how often exercises should be performed (frequency) and the optimal duration of an exercise programme, with different frequencies and durations (range from 4–12 weeks) leading to beneficial effects for individuals with RCRSP (McConnell et al., 2022). The available evidence indicates, with the possible exception of those with low levels of pain catastrophising, the absence of a consistent dose-response relationship between exercise dose and clinical outcomes for individuals with RCRSP. Individual treatment goals, stage of rehabilitation, and symptom irritability may influence shared decision making about the optimal dose of exercise.

4.3 | Does the muscle contraction type matter?

The early success and subsequent popularity of eccentric exercise for Achilles tendinopathy (Alfredson et al., 1998) inevitably led to its exploration for RCRSP (Camargo et al., 2014). Mirroring the initial promising results for Achilles and patellar tendinopathy, eccentric exercise for RCRSP was associated with improvement in shoulder pain and function (Holmgren et al., 2012; Maenhout et al., 2013). However, as more studies were performed, the results gradually tended towards eccentric exercise, which was no better than concentric (Blume et al., 2015) or isotonic (Dejaco et al., 2017) exercise. The most recent systematic review and meta-analysis exploring the effects of eccentric exercise for RCRSP formalises this regression towards equivalence (Larsson et al., 2019).

Similar to the substantial interest in eccentric exercise based on preliminary results in the Achilles and patellar tendons, isometric exercise enjoyed a surge in popularity after the publication of a seminal paper by Rio et al. (2015), showing the analgesic effect of an isometric contraction for patellar tendinopathy. When testing the effectiveness of isometric exercise for people with RCRSP, the best

available evidence suggests it is no better than simple ice therapy (Dupuis et al., 2018; Parle et al., 2017). For tendinopathy in general, isometric exercise does not appear to be superior to isotonic exercise for immediate pain relief or clinical outcomes (Clifford et al., 2020). So, is there a best contraction type? Not according to the evidence.

4.4 | Should exercise be supervised?

Current meta-analyses report no differences between supervised and unsupervised exercise for individuals with RCRSP (Gutierrez-Espinoza et al., 2020; Liaghat et al., 2021). An RCT published since, compared a supervised physiotherapist-led training regimen with an education and exercise leaflet, following a corticosteroid injection for both groups (Roddy et al., 2020). At 6 months of follow-up, the supervised physiotherapist-led exercise group demonstrated a significant improvement in shoulder pain and function. There was no difference at 6 weeks and 12-month follow-ups. A possible explanation for these results was the disproportionately higher exercise adherence in the supervised exercise group compared with the unsupervised group. Based on the available evidence, decision making on the level of supervision of an exercise programme should be made with consideration of individual patient circumstances.

4.5 | Should pain be permitted during exercise?

A systematic review and meta-analysis found that painful therapeutic exercise was not a barrier to experiencing a successful outcome with exercise therapy for a variety of musculoskeletal conditions (Smith et al., 2017). In fact, at short-term follow-up, exercising into pain was significantly better (Smith et al., 2017). Within this meta-analysis, three of the included studies were classified as RCRSP (Holmgren et al., 2012; Littlewood et al., 2016; Maenhout et al., 2013). There were no significant differences in long-term outcomes between exercise programs that permitted pain and those that prohibited pain. In the short-term, the Holmgren et al. (2012) trial demonstrated that painful exercises (up to 5/10 on a 0–10 scale) were associated with superior outcomes (Holmgren et al., 2012). This does not imply that permitting painful exercise causally explains the superior benefits observed at short-term follow-up, or any time frame, but it does demonstrate that exercising into pain need not be avoided or demonised as a rule. Further research is required to corroborate this conjecture. Individual circumstances will of course dictate the level of pain permitted, if any, and it is conjectured that exercising into pain when pain catastrophising is high could be counterproductive (Clausen et al., 2023).

The common view that there is no best exercise approach (on average) for helping individuals with RCRSP is thus supported, and uncertainty envelops much of the implementation of exercise therapy.

5 | WHAT CAN WE LEARN FROM THE LIVED EXPERIENCE OF INDIVIDUALS WHEN IT COMES TO EXERCISE FOR RCRSP?

It would be remiss to explore the role of exercise in managing RCRSP without considering the lived experience of individuals. Qualitative research reveals that participants randomised to an exercise-arm of a clinical trial can feel disappointed and sceptical, preferring a manual therapy-based approach (Littlewood et al., 2014). Conversely, other research highlights that some individuals prefer exercise-based rehabilitation due to previous failure of traditional hands-on approaches (Littlewood et al., 2014; Powell et al., 2023). This is concordant with recent research illustrating that individuals often want and expect exercise from their physiotherapist, as described by a participant in the Subialka et al. (2022) qualitative assessment (Jensen et al., 2022; Subialka et al., 2022):

I'm just looking for them to teach me how to do the exercises I need to do at home to keep that range of motion going and to knock that pain level down without major surgery.

(Subialka et al., 2022)

A qualitative investigation exploring how and why individuals with lived experience of RCRSP believed exercise helped their symptoms reported that all participants in the study had a positive experience with exercise, but only under certain conditions (Powell et al., 2023). Foremost among these conditions was the therapeutic relationship with their treating clinician, in which a failure to build a strong therapeutic relationship led to the inevitable failure of prescribed exercises. Another identified clinical condition, in this study and others (Sandford et al., 2017), was the importance of an individualised exercise programme, rather than a seemingly generic regimen.

Yeah, it felt like it was a more tailored approach to me about me getting better as opposed to just a cookie cutter; here's a default programme for six to eight weeks that should make you better. Everyone does the same thing approach.

(Powell et al., 2023)

Other commonly expressed barriers to engaging with an exercise programme are poor access to equipment, uncertainty about approximate recovery timeframe, lack of motivation and time, and beliefs and expectations about whether exercise is the appropriate treatment for their shoulder pain (O'Shea et al., 2022; Sandford et al., 2017). Conversely, cogent advice and education about their shoulder condition and how to perform their exercise programme, access to equipment, lack of exercise burden, and a supportive social network were key facilitators of engaging with an exercise programme (O'Shea et al., 2022; Sandford et al., 2017).

The qualitative literature highlights the complexity and context-

dependency of an individual's experience engaging with an exercise programme. However, when provided within the appropriate clinical context, exercise is often expected, wanted, and for the most part, positively received by individuals with RCRSP.

6 | HOW DOES EXERCISE HELP INDIVIDUALS WITH RCRSP?

The pursuit of effective treatments for RCRSP is of paramount research importance. Another important aim of clinical research, and science in general, is to generate causal explanations of how a particular treatment caused a particular outcome. While hundreds of effectiveness trials exist testing exercise and other treatments for RCRSP, research focused on the specific identification of causal explanations (mechanisms) is sparse. A scoping review by Powell et al. (2022a, 2022b) identified 32 unique causal explanations that have been proposed for the beneficial effect of exercise for individuals with RCRSP, of which the vast majority pertained to traditional biomechanical mechanisms such as muscle strength, motor control, and acromiohumeral distance (Powell et al., 2022b). Very few of these biomechanical causal explanations have been tested, much less verified, by appropriate experimental and statistical methods and remain hypothetical (Powell et al., 2022b; Powell & Lewis, 2021).

Mediation analysis is an empirical method of ascertaining how a treatment causes an outcome (Lee et al., 2021); for example, how does resistance exercise reduce shoulder pain? Mediation analyses investigating the causal mechanisms of exercise for shoulder pain are scarce and only two could be identified at the time of writing (Gutierrez Espinoza et al., 2023; Hotta et al., 2022), of which, both warrant discussion. Hotta et al. (2022) conducted a secondary mediation analysis of an RCT which compared general periscapular muscle strengthening exercises to general periscapular muscle strengthening plus scapular stabilisation exercises (Hotta et al., 2020, 2022). They reported that scapular motion, position, and muscle strength did not mediate shoulder pain and disability outcomes in people with RCRSP.

Gutierrez Espinoza et al. (2023) conducted an RCT comparing specific exercises to general exercises for people with RCRSP. For clarity, the specific exercises aimed to improve scapular orientation, both static and dynamic, and to optimise the position of the humeral head in the glenoid to prevent superior translation (presumably to avoid subacromial impingement). The general exercises were targeted towards improving the strength, mobility, and coordination of the shoulder girdle to 'unload' the subacromial space. The results of the trial showed a significant improvement in shoulder pain and disability in favour of the specific exercise group, but the difference was not clinically meaningful. Interestingly, the effect of the specific exercise programme was reported to have been partly mediated through a reduction in kinesiophobia, possibly representing a treatment target for clinicians with patients who present with higher levels of kinesiophobia. It is unclear what aspect of the specific exercise programme led to a reduction in kinesiophobia, or whether this could be achieved

via other exercise approaches. For example, qualitative research highlights that individuals express a reduction in kinesiophobia via simple strengthening-based exercise (Powell et al., 2023).

In the qualitative research literature, when individuals with lived experience of RCRSP were asked about how exercise helped their shoulder pain, the following three mechanisms were frequently reported: (1) improvements in muscle strength, (2) changes to psycho-emotional status, and (3) the acknowledgement of the widespread positive health effects of exercise (see Table 1 for supporting quotes) (Powell et al., 2023). Patient perceptions of exercise mechanisms approximate those proposed in the scientific literature in relation to shoulder strength but differ in the level of importance attached to psycho-emotional mechanisms (Powell et al., 2022b).

At this stage, there is a void of knowledge regarding the causal mechanisms for improvement associated with exercise for RCRSP. However, current evidence indicates that traditional targets of exercise, including increasing muscle strength, optimising scapular position and motion, and increasing acromiohumeral distance, may not explain clinical improvements in shoulder pain and function (Powell et al., 2022b; Powell & Lewis, 2021). Psychological constructs, such as kinesiophobia and pain self-efficacy, are promising mediators and treatment targets, but more research is needed to corroborate this hypothesis. Another possible mechanism is restoring biochemical homeostasis to the shoulder tissues (Docherty et al., 2022), but this too needs further research. At this juncture, we recommend clinicians refrain from providing definitive monocausal explanations for the effect of exercise (e.g. optimising scapular movement, improving strength) and rather advise that exercise may help reduce shoulder pain and improve shoulder function via a number of inter-related biopsychosocial mechanisms (Powell & Lewis, 2021). Further research is crucial to understanding the causal pathways through which exercise confers a benefit to individuals with RCRSP, which may improve the implementation and clinical outcomes of exercise therapy.

7 | NAVIGATING UNCERTAINTY: THEORETICAL CONSIDERATIONS FOR USING EXERCISE THERAPY

The current societal burden of musculoskeletal pain is profound and is only expected to increase (Blyth et al., 2019; Diseases & Injuries, 2020). This is predicted to increasingly strain already strained health care systems, and as such, physiotherapists are encouraged to

provide high-value care (Cook et al., 2021; Gleadhill et al., 2023). High value care is defined as delivering an intervention where the probability of benefit exceeds probable harm (Elshaug et al., 2017). For many non-traumatic musculoskeletal conditions, including RCRSP, the benefits of various surgical and non-surgical interventions are equivalent and modest, making it a clinical challenge to select an obvious high value treatment for an individual seeking care. Perhaps another way to approach the provision of value-based care is *high quality care* (Gleadhill et al., 2023) or the *right care*. In 2017, the Lancet published the *Right Care Series* and defined the *right care* as 'care that is tailored for optimising health and wellbeing by delivering what is needed, wanted, clinically effective, affordable, equitable, and responsible in its use of resources' (Elshaug et al., 2017). Exercise for RCRSP is modestly effective (Babatunde et al., 2021; Naunton et al., 2020; Steuri et al., 2017), often desired (Maxwell et al., 2021; Powell et al., 2023; Subialka et al., 2022), relatively affordable, and cost-effective (Oppong et al., 2021). We submit that exercise is equitable and responsible in its use of resources, certainly when compared to surgery for the majority of cases (Lewis, 2022). Exercise therapy can also be delivered in a timely fashion, without intensive supervision or extensive delay, and has been shown to be effective for patients on a waiting list for shoulder surgery (Holmgren et al., 2012). Whether it is needed in a particular clinical scenario should be a shared decision-making process between the individual seeking care and the treating clinician (Hoffmann et al., 2020).

Shared decision making is a dynamic process in which the clinician and patient are empowered to make health care decisions collaboratively, with due consideration of the benefits and harms of available treatment options, and the individual patient preferences, values and circumstances (Hoffmann et al., 2020, 2022). Shared decision making is considered appropriate when there is not one clearly superior treatment approach available (Hoffmann et al., 2022). This applies to both selection of a treatment, such as exercise, and also to the delivery of a chosen treatment, such as the exercise parameters. As emphasised in Section Four of this paper, uncertainty underpins much of the provision of therapeutic exercise for an individual with RCRSP, and in such cases it is considered best practice to invoke shared decision making when choosing and implementing a treatment. What this looks like in clinical practice will be expounded upon in Section Eight. It must be emphasised that exercise is one, but not the only, option to help an individual diagnosed with RCRSP;

TABLE 1 Causal mechanisms of exercise expressed by individuals with lived experience of rotator cuff-related shoulder pain.

Causal mechanisms	Supporting quotes
Improvement in muscle strength	'And then the second I started strength training, I felt, yeah, just doing one exercise, every part of my shoulder was engaged. I was feeling that instant connection between the exercise I was doing and a positive improvement in my shoulder' (Powell et al., 2023)
Changes to psycho-emotional status	'Just restoring that faith in my shoulder, I suppose, which is what he got me to eventually do with all of the strength exercises' (Powell et al., 2023)
Exercise has widespread positive health effects	'It's a positive. It's beneficial. Feels good [exercise]... Obviously exercise is a good thing, if done right. It's good for joints. It's good for muscle. It's good for tendons. It's good for ligaments. It's good for strength. It's good for mental health' (Powell et al., 2023)

however, because exercise therapy appears to largely satisfy the *right care* criterion, we propose it is well placed to remain a principal treatment option for RCRSP.

8 | NAVIGATING UNCERTAINTY: PRACTICAL CONSIDERATIONS FOR USING EXERCISE THERAPY

If the shared decision is to proceed with a trial of exercise therapy, in conjunction with appropriate advice and education (Dube et al., 2023), how might one construct an effective programme given the enduring uncertainty surrounding much of its implementation? (Figure 1).

If the aim of exercise is to reduce shoulder pain, there are many approaches that may be considered. The uncertainty of how exercise causes a reduction in shoulder pain means the identification of traditional exercise targets, including weak and tight muscles, and aberrant scapular motion and position, need not dictate the selection of exercise type. With this in mind, the clinician is encouraged to select an exercise type and progression that they, and most importantly the patient, are most comfortable with, and has the least number of barriers (financial, exercise complexity, time constraints etc.) for adherence, and is tailored to their clinical presentation. If the clinician and patient agree to trial a form of resistance exercise, the type of contraction (isometric/isotonic/eccentric), the intensity of exercise, and the overall dose of the exercises will largely depend on what the patient can tolerate at the time and their goals for rehabilitation. There is inherent flexibility in

this, will likely vary from patient to patient, and should be fit for purpose. Clinicians might consider conducting 'exercise experiments', similar to behavioural experiments described in the Shape-Up-My-Shoulder rehabilitation programme (Lewis et al., 2022) and the cognitive functional therapy literature (O'Sullivan, 2018), where exercise type, intensity, and context are trialled and adjusted based on the patient response. An approach similar to this has been described as being helpful by individuals with lived experience of RCRSP (Powell et al., 2023). This approach makes space for a plurality of exercise and movement types and parameters to be trialled depending on the individual's symptom irritability, preferences, and feedback. The level of physiotherapist supervision will be an important conversation between the clinician and patient, and in the absence of robust evidence to sway clinical decision making one way or the other, this will depend on the specific clinical scenario. However, physiotherapists are encouraged to transparently communicate the equal effectiveness of supervised and unsupervised exercise for RCRSP and allow the patient to come to their own decisions. When it comes to pain during exercise, rather than dogmatically allowing or avoiding pain, the clinician is encouraged to gently explore the nature of any pain experience with a particular exercise or movement (Table 2), assuming a therapeutic alliance has first been established. The information derived from this exploration may be used to facilitate the collaborative construction of a tailored exercise programme (Powell et al., 2023). This 'Darwinian' approach to exercise selection means that only the most appropriate exercises for an individual with RCRSP will survive and make it into a programme.



FIGURE 1 Clinical uncertainty of delivering therapeutic exercise for rotator cuff-related shoulder pain.

TABLE 2 Questions to help clinicians navigate shoulder pain during an exercise experiment.

Example questions	Possible information gathered from questions
Question: Is the pain you're experiencing during this exercise familiar, or does it feel different?	This could help decipher whether the pain is related to a 'muscle burn' or is provocative of their familiar (normal) pain. If the pain is more related to a 'muscle burn', the exercise need not be dramatically modified, provided the patient can tolerate the intensity
Question: Does the pain settle when you stop the exercise? Follow-up Question: How long after?	This can help guide decision making about whether the patient can tolerate this exercise, done this way, at this time. Typically, it is advised that their familiar pain return to baseline levels within 30 min of performing the exercise. Some delayed onset muscle soreness should be expected in the following days
Question: What are your thoughts and feelings during this exercise?	This question may reveal whether there are unhelpful beliefs about movement and pain, which could lead to further discussion about whether these beliefs are impacting their recovery or how well they correspond to known evidence
Question: Do you think your pain is changeable? What happens to your pain if we: • Change the load? • Change the ROM? • Change the lever (moment arm)? • Change the plane of movement? • Change the contraction type? • Try in a different position? (e.g. side lying vs standing)	This part of the exercise experiment is important and may provide information about the movements and loads your patient can tolerate at this time. This information can subsequently guide creation of a tailored exercise programme. Experiencing a reduction in pain by adjusting movement, load, or context could reinforce to the individual that their pain is modifiable, perhaps leading to renewed confidence of a positive outcome
Question: How does your pain respond with more repetitions of exercise? Does it get better, worse, or stay the same?	Pain that gets better with more repetitions could indicate low symptom irritability and might greenlight a larger exercise dose. Pain that worsens with more repetitions might mean a lower dose exercise programme is needed in the short term. Unchanging pain could be amenable to either, in a trial-and-error approach
Question: Would you feel confident performing this exercise, with this level of shoulder pain, unsupervised at home? Follow-up question: Would you feel confident progressing/regressing the exercise based on the evolution of your symptoms?	These questions can give you an insight into the depth of understanding and self-efficacy an individual has about a particular exercise programme. Ideally, the individual will feel empowered and confident to take control of their exercise programme and recovery and be able to engage with the programme unsupervised

As the pain settles, the clinician and patient might start to think about using exercise to enhance the physical function and performance of the shoulder, perhaps to facilitate a return to work or a recreational pursuit that demands moderate use of the shoulder. In this clinical scenario, it is logical to start thinking about exercise from a classical biomechanical standpoint. Is there a certain level of shoulder strength required for their job, sport, or recreation? If so, extra thought might be given to principles of strength and conditioning, such as exercise intensity, volume, and frequency. Will the shoulder be required to tolerate repeated loads? If so, perhaps more thought should be directed towards contraction type, including plyometric type exercise. What kinds of movements will be expected of the shoulder? Various combinations of pushing, pulling, lifting, raising, rotating, and carrying can be incorporated into an exercise programme to best prepare the shoulder for return to work, sport, or recreation. Rehabilitation can also include the kinetic chain (Richardson et al., 2020). A useful heuristic to help guide exercise-based rehabilitation for clinicians is that specificity of exercise type, intensity, volume, and contraction type seems to matter little for reducing the experience of shoulder pain but might matter more for enhancing shoulder function and performance.

9 | CONCLUSION

Exercise therapy is a versatile and for many an effective treatment option to use in the management of RCRSP. Crucially, exercise appears to largely satisfy the right care criterion and can be delivered in a timely and unsupervised fashion, which may demarcate it from other common musculoskeletal treatments. However, as this critical review has highlighted, uncertainty underpins much of the delivery of therapeutic exercise, and it may not be suitable for everyone. There is uncertainty about the optimal anatomy of an exercise programme, but this does not preclude action. The use of exercise experiments may help guide exercise selection in a way that naturally tailors an exercise programme appropriate for an individual. We recommend the continued consideration of exercise therapy for appropriate individuals with RCRSP governed by a shared decision-making process and acknowledge the considerable research to be done to improve our understanding of the role exercise plays in helping individuals with RCRSP.

AUTHOR CONTRIBUTIONS

Jared K. Powell, Ben Schram, Jeremy Lewis, and Wayne Hing conceived and designed the manuscript. Jared K. Powell was the lead author. Jared K. Powell drafted the manuscript, and all authors were

involved in the subsequent editing process and approval of the final version of the manuscript.

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JKP and JL have received remuneration for the provision of continuing professional development courses on shoulder rehabilitation.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no datasets were generated or analysed during this study.

ETHICS STATEMENT

Not applicable to this review.

OFAC STATEMENT

All authors of this review are acting exclusively in a personal capacity.

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APPENDIX 8: ARTICLE TITLE PAGE AS SUBMITTED TO SHOULDER AND ELBOW

Assessing the effectiveness of exercise therapy for rotator cuff-related shoulder pain from a novel perspective. What can we learn from applying Bradford Hill's viewpoints of causality?

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