Musculoskeletal Rehabilitation: Assessment and Management of the Rotator Cuff Mini Series

Session Three: Pain & non-responders

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Assessment & Management of the 'Rotator Cuff': An evidence-based approach

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Session three: Pain and non-responders

In this session we will consider pain mechanisms in rotator cuff tendinopathy in tandem with thinking about why our treatments might, or might not work. This will lead into an analysis of the options to consider if our patients are not responding to treatment. This will include the role of corticosteroid injections, surgery and possible new treatment avenues.

Intended learning outcomes

1. To explore current thinking in relation to pain and rotator cuff tendinopathy

2. To develop understanding of other treatment approaches, including surgery and corticosteroid injections, in non-responding patients

3. To develop skills of reflective practice.

Pain and rotator cuff tendinopathy

The following section is adapted from Littlewood et al (2013). The central nervous system - An additional consideration in 'rotator cuff tendinopathy' and a potential basis for understanding response to loaded therapeutic exercise. Manual Therapy, 18 (6). 468-472.

Tendinopathy is a term commonly used to describe tendon pathology and/or pain. Despite being a well-recognised clinical presentation, a definitive understanding of the pathoaetiology of rotator cuff tendinopathy remains elusive [1]. Over recent years there has been a focus upon understanding pain associated with tendinopathy from the perspective of local tissue based pathology. But, in light of the well-recognised dissociation between pathology and pain [2], it is becoming clear that additional explanatory models are now needed [3].

In view of this, the aim of this paper is to present a theoretical extension to current models incorporating the integral role of the central nervous system (CNS) in the pain experience. For the purpose of clarity within this paper and to aid clinical translation, the terminology 'rotator cuff tendinopathy' refers to a presentation where a person complains of shoulder pain with movement that is provoked further with load, for example lifting or through resisted tests performed by a clinician during a physical examination [4]. We recognise that the reader might object to or question the appropriateness of the term rotator cuff tendinopathy for two reasons. Firstly, the criteria we use to define rotator cuff tendinopathy is broad and might include a range of biomedical diagnoses, including subacromial impingement, subacromial bursitis, rotator cuff tear, acromioclavicular joint osteoarthritis etc. However, in the absence of evidence to support the validity or reliability of such diagnoses [5], particularly in relation to the lack of association between pathology and pain, it is difficult to substantiate such an objection. Secondly, in the context of attempts to highlight the role of the CNS, such specific pathology or impairment terminology might be regarded as a backwards step because of their reference to specific peripheral tissue or mechanical mechanisms. However, such a broad definition of tendinopathy in this translational paper is deliberate and purposeful to highlight how current practice models can be interpreted and usefully enhanced without wholesale, probably unrealistic, changes to practice and terminology; hence there is pragmatic value.

A secondary aim is to offer one hypothetical rationale to explain the response to therapeutic exercises reported by previous studies [6–9]. These further considerations have the potential to offer a useful basis upon which to explain pain to patients and for clinicians to prescribe appropriate therapeutic management strategies.

Local tissue pathology-pain models

This paper will begin by offering a critique of local pain models as a basis upon which to justify the need for greater consideration of the CNS. Tissue based pathology-pain models have been proposed [2] and adapted to the rotator cuff [1]. However, as mentioned, these models are confounded by the lack of association between pathology and pain [2,3]. Using magnetic resonance imaging, Frost et al. [10] could not distinguish individuals diagnosed with subacromial impingement from asymptomatic age-matched controls according to structural pathology. In keeping with this, asymptomatic rotator cuff tears are common in the general population with estimates ranging between 7 and 72% [11–13]. Studies investigating prognosis [14] have suggested that the biomedical diagnosis, relating to specific tissues at fault, was not associated with clinical outcomes. Furthermore, it has been reported that structural change does not explain response to therapeutic exercise because as clinical outcomes improve a corresponding change in observable structural pathology is not seen [3]. Hence, in the context of this literature, traditional models that describe tissue injury/ structural pathology resulting in nocioceptive input and a pain response in proportion to the extent of injury seem inadequate, if considered in isolation.

Local biochemical models

In light of the shortcomings of local tissue pathology-pain models, others have suggested a local biochemical basis for the pain associated with tendinopathy where biochemical mediators in the tissue stimulate nocioceptive afferent fibres [15]. Degenerative pathology is associated with neurovascular ingrowth and potential pain mediators such as substance P and acetylcholine. However, it remains unclear whether biochemical substances are a cause of tissue degradation and/ or pain or whether they are a by-product of tendinopathy [16]. But, because biochemical models make no assumption about the underlying pathology, such biochemically driven nocioceptive pathways might offer further understanding of symptomatic versus asymptomatic pathology.

So, in light of what is currently known, local biochemical models appear to have the potential to enhance understanding and management of tendinopathy. But, neither these or local tissue pathology-pain models recognise the role of the CNS nor critically that nocioception is neither sufficient nor necessary for a pain experience [17].

Background to the role of the CNS

A contemporary understanding of pain suggests that there might be other mechanisms involved in pain associated with tendinopathy that might act with the local mechanisms outlined above or in isolation. The notion that the state of the tissue does not provide an adequate measure of pain is recognised in relation to other pain syndromes [17,18] but in tendinopathy local tissue/biochemical based models are predominantly used to explain pain [1,2,19]. Such models continue to be developed but fail to adequately recognise the integral role of the CNS, or perhaps more accurately the person, in the pain experience. This omission neglects a whole body of pertinent literature, that might offer some further explanation as to why attempts to link symptoms to peripheral structural pathology continue to fall short [17,20].

We suggest here that the pain associated with rotator cuff tendinopathy, that persists beyond expected recovery times, should be evaluated within a framework that recognises the potential for altered processing and modulated output of the CNS rather than solely a product of peripherally driven nocioception secondary to persistent tissue abnormality, for example tendon degeneration or tear. Note that we have used the term recovery time as opposed to healing time because many studies suggest that the rotator cuff does not always ‘heal’ from a structural perspective, even after attempts to surgically repair torn tissue [21,22] although symptoms might still improve over time. In this context it is difficult to define a definitive time point by which we can assert that peripheral

tissue recovery has been completed in terms of the inflammatory and proliferative stages. It is likely that this point will be highly individualised and compounded by factors specific to the rotator cuff including the relative hypovascularity of the tissue [1,22]. In practice, it might be more important to consider factors other than time-course of symptoms when considering whether local or CNS pain mechanisms predominate.

Explaining pain

The following section describes the potential mechanisms involved in pain associated with rotator cuff tendinopathy. The aim is to offer a reasoned explanation as to why pain state or output might persist and might not be proportionate to the state of the rotator cuff tissue. In addition to enhancing understanding of pain mechanisms, one further consequence of this might be a direct challenge to current practice where, for example, prescription of loaded exercise is limited due to fear of causing tissue damage [23].

Central mechanisms

We begin by considering potential aberrations relating to processing of afferent inputs at the spinal cord level. Central sensitisation is a state that has been described in terms of altered processing where dorsal horn cells in the spinal cord become increasingly sensitised [24]. In this altered state even non-noxious input, for example lifting the arm, can contribute to a painful output [24]. Gwilym et al. [25], recognising that anomalies existed between peripheral tissue structure and the degree of pain experienced, proposed the presence of central sensitisation in a significant proportion of their patients who underwent subacromial decompression. Furthermore, those patients who were regarded as having greater levels of central sensitisation pre-operatively reported worse outcomes three months following the operation. Clearly, pain mechanisms beyond peripherally driven nocioceptive mechanisms are in play here and the study by Gwilym et al. [25] casts further doubt upon the validity of tissue state as the sole basis upon which to understand pain.

Although central sensitisation is often described as being a product of a barrage of afferent impulses, maybe secondary to acute tissue injury, it is now well recognised that this hyper-reactive state of the dorsal horn cells can persist in the absence of on-going afferent input, known as pain memory [24]. This reflects the plasticity or adaptability of the CNS. So, even in the presence of a recovered peripheral tissue, for example a rotator cuff tendon, central sensitisation can continue to contribute to an on-going pain state where non-noxious input contributes to a painful output.

Pain as an output

Pain as an output, in response to a threat, is regarded as a protective mechanism which might be helpful in some acute situations, where the primary aim is to minimise further threat, but unhelpful in other situations where unhelpful interpretation of a pain response serves as a barrier to recovery [17,18]. An example of this would be resting a shoulder that needs movement to facilitate functional restoration. The key feature proposed here is that pain is a product of CNS processing, at the level of the spinal cord and the brain, which is modulated by other factors including thoughts and feelings, and does not necessarily reflect the state of the peripheral tissues, at least from an observable structural perspective. CNS modulation might be influenced by a range of intrinsic inputs, for example beliefs about what the pain means, or extrinsic inputs, for example, societal context. To highlight this, a person who has been advised to rest, believing that their shoulder pain is caused by tissues being compressed and catching is likely to present in a different way to someone who has been reassured and given guidelines about how best to get their arm moving. In this context it is perhaps possible to see how the subacromial impingement model might adversely contribute to the pain experience and rightfully is now regarded as an outdated and unhelpful way to understand shoulder pain [26,27].

The Mature Organism Model

To facilitate understanding and implementation, Gifford [28] proposed the mature organism model (MOM). This model describes a cyclical process beginning with an input to the CNS (sampling), for example nocioception. This is followed by CNS processing (scrutiny) before an output, for example an altered behaviour, is generated. The output subsequently serves as a further input to the sampling loop. The MOM suggests that the CNS is continually sampling tissue health, the surrounding environment and itself, consciously and unconsciously, before scrutinising this input in the context of past experience, knowledge, beliefs, culture, past successful behaviour, past successful behaviour observed in others [28,29]. This process of scrutiny before an output is generated is key and has the potential to create an environment for recovery or otherwise. For example, if this scrutiny takes place in the context of a subacromial impingement model, it is possible that an already de-conditioned tissue is allowed to de-condition further if any sign of pain is interpreted as impending tissue damage and is hence avoided.

The de-conditioned rotator cuff

Perhaps one immediate question that arises is: Why would the CNS generate a painful output that is not directly related to the pathological status of the tissue? We believe that this can be understood in terms of a protective pain output from the CNS in response to a perceived threat to a de-conditioned tissue. We use the term de-conditioned to describe a situation where the CNS perceives the tissue to have a reduced capacity to perform required tasks [30]. It is the perceived nature of the de-conditioning and hence protective pain output from the CNS that might offer an alternative explanation as to why observed structural changes do not adequately explain pain, although subtle mechanical changes to the tissue that might not appear on imaging cannot be fully discounted at this stage [31]. It should be recognised that de-conditioning does not mean degeneration, although degenerated tissue might be de-conditioned and tissues that have been injured previously might become de-conditioned, but not necessarily so.

The source of de-conditioning in relation to the rotator cuff is open to debate but some speculative claims can be offered within a biopsychosocial framework. In terms of biology, factors including relative hypovascularity and adverse mechanical loading might be relevant. Also underuse, whereby physical stress levels perhaps secondary to a sedentary lifestyle, are lower than the maintenance range, and result in decreased capacity of the tissues [32]. A biological theory appears plausible where studies have reported a reduction in tendon capacity with age [33] in tandem with an epidemiological perspective where studies have reported increasing prevalence rates of rotator cuff tendinopathy with age [34]. In terms of psychology, a broad range of attitudes, beliefs and experiences might contribute to this perceived de-conditioning. For example, a belief that; ‘I’ve inherited weak shoulders so I’m limited in what I can do,’ or a past experience that resulted in a pain response might long be held in the memory and inform any future central scrutiny. From a social perspective, again many factors could contribute. The role of the health care professional and diagnostic labels was described above to demonstrate how a context can influence behaviour. Many studies have reported how the perception of pain varies across gender, race and age. It seems likely that a combination of these biopsychosocial factors might (mis)inform an individual’s perception and hence pain response.

Rationale for response to therapeutic exercise

From a biological perspective initially, tendons are regarded as being mechanosensitive, which means they are capable of responding to mechanical stimuli [35]. The term ‘mechanotherapy’ has been coined to describe how a programme of structured exercise might stimulate human tissue and reverse tendon de-conditioning [33,36,37]. It has been proposed that a progressive exercise regime will stimulate a process of re-conditioning and improve the capacity of the rotator cuff to withstand greater load and stress [33,38,39].

Due to the paucity of evidence, the optimal load to stimulate re-conditioning remains unclear. However, when reporting favourable outcomes, recent studies have encouraged load prescription according to symptom response where pain was produced during exercise [6,7,9,40]. Such an approach might initially appear counter-intuitive within the context of the framework described here but we suggest that quite the opposite is true.

Drew et al. [3] reported that observable structural change does not adequately explain response to therapeutic exercise and that other mechanisms are more likely to be responsible. In addition to local biological changes, it is feasible that appropriate prescription of therapeutic exercise has an impact upon CNS scrutiny or processing with a resultant modified output. From a psychological perspective, the prescription of painful loaded exercise within a framework that suggests hurt does not equal harm; hurt, in some circumstances, equals a tissue that is de-conditioned and needs using/exercising, has the potential to reframe the meaning of pain. In addition to this, a progressive exercise programme has the capacity to address the hypothesised de-conditioning as the frequency and load of exercise increases over time. Basically, if the way a person conceives their shoulder pain is adapted then there is potential for beneficial change in CNS output to be realised, particularly if the prescribed exercise programme resembles their usual functional activities. Clearly in this context, intelligent but individualised prescription of painful therapeutic exercise and return to normal function is required that does not provoke a threat response from the CNS in terms of a lasting and exaggerated pain output. In practice this requires that our patients have an understanding of why the exercise has been prescribed, that hurt does not equal harm, in their circumstance, and it requires an understanding of the patient's acceptable pain response. Although an inexact science for which the boundaries have not yet been adequately defined, acceptable pain responses can be elicited through simple questioning, for example; 'Is that amount of pain acceptable to you while you are exercising or after you have exercised? Should we add more/ less load?'

For such exercise prescription to be effectively implemented, the therapist must be mindful of the perspectives held by the patient. We suggest simple exploratory questions such as: What do you understand is the cause of your problem? Such questioning can help to elicit understanding and begin to identify potential barriers to implementation. Finally, from a social perspective, in terms of the influence of surroundings and significant others, the prescription of loaded exercise within this framework challenges diagnostic and therapeutic approaches that promote fear avoidance, for example 'the pain is a sign of further tissue damage so don't move it if it is painful.' Such prescription also has the potential to challenge public perception that hurt equals harm in all circumstances. As opposed to some previous approaches, a constructive, non-threatening means around which restoration of function can be achieved is offered.

Clearly the pain associated with 'rotator cuff tendinopathy' has a multi-dimensional basis. The key to future success will be to discover indicators of each dimension along with reasoned and relevant multi-dimensional management strategies. More will be discussed during the webinar in relation to this including reference to the growing body of literature relating to lifestyle factors such as smoking, obesity and physical inactivity and hence new opportunities to develop new interventions.

The primary message from this paper can be summarised as a process beginning with perceived tissue de-conditioning, secondary to a known or unknown cause, for example chronic underuse. An episode of relative overuse or overload results in short term tissue responses that are scrutinised by the CNS in the context of other inputs and the surrounding environment and if the input is regarded as a threat, a painful output as a means of protection will ensue. In this situation this might promote

avoidance of shoulder movement if the pain is believed to be indicative of harm, and will also result in a unique pain experience, for example absence from work and low mood due to activity withdrawal. Such fear avoidance might result in further tissue de-conditioning and a continuation of the cycle. However, appropriate contextualisation and intervention might result in a different outcome. If pain is regarded as a sign of de-conditioning rather than actual or impending tissue damage then an alternative process of CNS scrutiny might result in an active output, for example engagement with a structured exercise regime, with the potential to re-condition peripheral (tendon) and central tissue. Additionally, active engagement and 'permission' to resume normal activity without fear of causing harm to self might facilitate an improved outcome in contrast to existing approaches.

Conclusion to this paper

The cause of pain associated with rotator cuff tendinopathy remains uncertain and there are clear limitations associated with current explanatory models that rely on a peripheral tissue based understanding. A theoretical addition to these pre-existing models has been presented with reference to current literature incorporating the integral role of the CNS in any pain experience. This additional consideration offers an accessible way to understand the pain associated with rotator cuff tendinopathy and to understand potential mechanisms underpinning therapeutic response to exercise.

Non-responders

In the final section of this webinar series we will consider those patients who do not respond adequately to the approaches described so far.

One intervention that appears to be frequently offered to non-responding patients is a corticosteroid injection. The research evidence to date suggests that these injections offer possible, small amounts of short-term relief, i.e. any positive effect is no longer apparent after three months [41]. However, Rhon et al. [42] undertook a randomised controlled trial that compared first line intervention with corticosteroid injection with physiotherapy. Perhaps unsurprisingly the clinical outcomes from both approaches were similar after 12 months. But, for the group who received a corticosteroid injection, they required more visits to their primary care physician, more corticosteroid injections, and more physiotherapy to achieve the same outcomes as the group who received physiotherapy as the first line intervention. So, the possible small short-term effects of this intervention need to be considered in the context of the likelihood of the patient requiring further interventions over the mid- to longer-term to attain the same clinical outcome – this is something that should be made clear to the patient if corticosteroid injection is recommended. Furthermore, Dean et al. [43] reported that local corticosteroid injections reduce cell proliferation and impair collagen synthesis. Given that we are unsure about the mechanisms of recovery of patients with rotator cuff tendinopathy, this effect does not seem desirable and again raises questions about the use of corticosteroid injections for patients with rotator cuff tendinopathy. Finally, in relation to corticosteroid injections, Coombes et al. [44] reported worse clinical outcomes and higher rates of recurrence following corticosteroid injections for Tennis Elbow compared to a placebo injection. Clearly this research evidence relates to a different clinical condition but given the results and the emerging evidence described above it seems sensible to suggest that we should be cautious when thinking about prescribing corticosteroid injections and we should aim to fully educate our patients about the potential implications of choosing this treatment option.

Surgery, typically subacromial decompression, is another intervention that might be considered for non-responding patients. This surgical approach has largely been justified through the subacromial impingement model where it was theorised that bony encroachment results in reduced subacromial

space with subsequent compromise of the rotator cuff and associated tissues. This hypothesis has been significantly challenged recently with the publication of the results of the CSAW trial: Can Shoulder Arthroscopy Work? [45]. The CSAW trial reported no significant difference between subacromial decompression and a placebo operation where the arthroscopes were introduced in to the shoulder but no tissue was removed. This randomised controlled trial raises interesting questions in relation to why patients report improvement after such an operation where the reported effects do not appear to be principally related to the removal of the tissue that is supposed to be the source of 'impingement'.

Furthermore, other randomised controlled trials have reported no difference between surgery in the short-, mid-, and long-term [46]. So, given this research evidence in tandem with the extra costs and risks associated with surgery, it also seems sensible to suggest that we should re-think the contribution of surgery for rotator cuff tendinopathy and again aim to fully educate our patients about the potential implications of choosing this treatment option as well as the suggested mechanisms of action.

So, where does this leave us when patients aren't responding? My suggestion is that we think about the issues raised in relation to the 'pain of rotator cuff tendinopathy' section and recognise that non-response is not necessarily about structural pathology or faulty biomechanics. Secondly, I recommend a return to the second webinar and the accompanying study notes in relation to the factors we need to consider to optimise exercise prescription. But, instead of just thinking about these concepts when our patients don't seem to be responding, instead, these principles need to be considered at the outset of treatment for all patients.

Overall summary and conclusions to this webinar series

It is apparent that much remains unknown in relation to the optimal approach to the assessment and management of rotator cuff tendinopathy. However, it seems that there are questions to be asked about current approaches to examination that rely on special orthopaedic tests and diagnostic imaging to infer that a specific structure is causing this pain.

As with approaches to assessment and diagnosis, there is no clear superior approach to treatment. Based on current research evidence, exercise appears to be a promising intervention and adding further modalities, for example manual therapy, or providing costlier interventions, for example surgery, does not appear to confer additional benefit.

Although exercise is a promising intervention we should be cautious when assuming the improvement that we see in our patients is a direct result of the exercise. Why exercise does or doesn't work in some patients remains unclear and we still have to better understand what the key principles are that should inform an optimal exercise programme.

Finally, we seem to be making progress but with this progress comes more questions. Given this we should remain mindful of this current uncertainty and continue to question our own assumptions and also those of others.

Reference List

[1] Lewis J. Rotator cuff tendinopathy: a model for the continuum of pathology and related management. Br J Sports Med 2010;44:918–23.

[2] Cook J, Purdam C. Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med 2009;43:409–16.

[3] Drew BT, Smith TO, Littlewood C, Sturrock B. Do structural changes (eg, collagen/matrix) explain the response to therapeutic exercises in tendinopathy: A systematic review. Br J Sports Med 2014;48. doi:10.1136/bjsports-2012-091285.

[4] Littlewood C, Ashton J, Chance-Larsen K, May S, Sturrock B. Exercise for rotator cuff tendinopathy: A systematic review. Physiotherapy 2012;98. doi:10.1016/j.physio.2011.08.002.

[5] May S, Chance-Larsen K, Littlewood C, Lomas D, Saad M. Reliability of physical examination tests used in the assessment of patients with shoulder problems: a systematic review. Physiotherapy 2010;96:179–90.

[6] Jonsson P, Wahlstrom P, Ohberg L, Alfredson H. Eccentric training in chronic painful impingement syndrome of the shoulder: Results of a pilot study. Knee Surgery, Sport Traumatol Arthrosc 2005;14:76–81.

[7] Holmgren T, Bjornsson H, Oberg B, Adolfsson L, Johansson K. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study. Br Med J 2012;344:e787.

[8] Littlewood C, Malliaras P, Mawson S, May S, Walters SJ. Self-managed loaded exercise versus usual physiotherapy treatment for rotator cuff tendinopathy: A pilot randomised controlled trial. Physiother (United Kingdom) 2014;100. doi:10.1016/j.physio.2013.06.001.

[9] Littlewood C, Bateman M, Brown K, Bury J, Mawson S, May S, et al. Self-managed exercise versus usual physiotherapy treatment for rotator cuff tendinopathy: a randomised controlled trial (the SELF study). Clin Rehabil 2016;30:686–96.

[10] Frost P, Andersen J, Lundorf E. Is supraspinatus pathology as defined by magnetic resonance impaging associated with clinical signs of shoulder impingement? J Shoulder Elb Surg 1999;8:565–8.

[11] Templehof S, Rupp S, Seil R. Age-related prevalence of rotator cuff tears in asymptomatic shoulders. J Shoulder Elb Surg 1999;8:296–9.

[12] Worland R, Lee D, Orozco C, Sozarex F, Keenan J. Correlation of age, acromial morphology, and rotator cuff tear pathology diagnosed by ultrasound in asymptomatic patients. J South Orthop Assoc 2003;12:23–6.

[13] Yamamoto A, Takagishi K, Osawa T, Yanagawa Y, Nakajima D, Shitara H, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elb Surg 2010;19:116–20.

[14] Littlewood C, May S, Walters S. Epidemiology of rotator cuff tendinopathy: a systematic review. Shoulder Elb 2013;5:256–65.

[15] Khan K, Cook J, Maffulli N, Kannus P. Where is the pain coming from in tendinopathy? It may be biochemical, not only structural, in origin. Br J Sports Med 2000;34:81–3.

[16] Danielson P. Reviving the “biochemical” hypothesis for tendinopathy: new findings suggest the involvement of locally produced signal substances. Br J Sports Med 2009;43:265–8.

[17] Moseley L. Reconceptualising pain according to modern pain science. Phys Ther Rev 2007;12:169–78.

[18] Melzack R, Wall P. The challenge of pain. vol. 2nd. London: Penguin books; 2008.

[19] Liu P, Maffulli N, Rolf C, Smith R. What are the validated models for tendinopathy? Scand J

Med Sci Sport 2011;21:3–17.

[20] Wand B, Parkitny L, O'Connell N, Luomajoki H, McAuley J, Thacker M. Cortical changes in chronic low back pain: current state of the art and implications for clinical practice. Man Ther 2011;16:15–20.

[21] Galatz L, Ball C, Teefey S, Middleton W, Yamaguchi K. The outcome and repair integrity of completely arthroscopically repaired large and massive rotator cuff tears. J Bone Jt Surg 2004;86:219–24.

[22] Rees J, Wilson A, Wolman R. Current concepts in the management of tendon disorders. Rheumatology 2006;45:508–21.

[23] Littlewood C, Mawson S, May S, Walters S. Understanding the barriers and enablers to implementation of a self-managed exercise intervention: A qualitative study. Physiother (United Kingdom) 2015;101. doi:10.1016/j.physio.2015.01.001.

[24] Gifford L. The "central" mechanisms. In: Gifford L, editor. Top. Issues Pain 1, Falmouth: CNS Press; 1998, p. 67–80.

[25] Gwilym S, Oag H, Tracey I, Carr A. Evidence that central sensitisation is present in patients with shoulder impingement syndrome and influences the outcome after surgery. J Bone Jt Surg 2011;93:498–502.

[26] Lewis J. Subacromial impingement syndrome: a musculoskeletal condition or a clinical illusion? Phys Ther Rev 2011;16:388–98.

[27] Cuff A, Littlewood C. Subacromial impingement syndrome – What does this mean to and for the patient? A qualitative study. Musculoskelet Sci Pract 2017;33:24–8. doi:10.1016/j.msksp.2017.10.008.

[28] Gifford L. Pain, the tissues and the nervous system: a conceptual model. Physiotherapy 1998;84:27–36.

[29] Jones M, Edwards I, Gifford L. Conceptual models for implementing biopsychosocial theory in clinical practice. Man Ther 2002;7:2–9.

[30] Butler D, Moseley L. Explain pain. Adelaide, Australia: Noigroup publications; 2003.

[31] Malliaras P, Cook J. Patellar tendons with normal imaging and pain: change in imaging and pain status over a volleyball season. Clin J Sport Med 2006;16:388–91.

[32] Mueller M, Maluf K. Tissue adaptation to physical stress: a proposed "physical stress theory" to guide physical therapy practice, education and research. Phys Ther 2002;82:383–403.

[33] Reeves N. Adaptation of the tendon to mechanical usage. J Musculoskelet Neuronal Interact 2006;6:174–80.

[34] Chard M, Hazleman R, Hazleman B, King R, Reiss B. Shoulder disorders in the elderly: a community survey. Arthritis Rheum 1991;34:766–9.

[35] Maffulli N, Longo U. How do eccentric exercises work in tendinopathy? Rheumatology 2008;47:1444–5.

[36] Abate M, Silbernagel K, Siljeholm C, A D lorio, D DA, Salini V, et al. Pathogenesis of tendinopathies: inflammation or degeneration? Arthritis Res Ther 2009;11:235.

[37] Khan K, Scott A. Mechanotherapy: how physical therapists' prescription of exercise promotes tissue repair. Br J Sports Med 2011;43:247–51.

[38] McKenzie R, May S. The Human Extremities: Mechanical Diagnosis & Therapy. Waikanee, New Zealand: Spinal Publications; 2000.

[39] Kjaer M, Langberg H, Heinemeier K, Bayer M, Hansen M, Holm L, et al. From mechanical loading to collagen synthesis, structural changes and function in human tendon. Scand J Med Sci Sports 2009;19:500–10.

[40] Bernhardsson S, Klintberg I, Wendt G. Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome. Clin Rehabil 2010;25:69–78.

[41] Littlewood C, May S, Walters S. A review of systematic reviews of the effectiveness of conservative interventions for rotator cuff tendinopathy. Shoulder Elb 2013;5:151–67. doi:10.1111/sae.12009.

[42] Rhon D, Boyles R, Cleland J. One-Year Outcome of Subacromial Corticosteroid Injection Compared With Manual Physical Therapy for the Management of the Unilateral Shoulder Impingement Syndrome: A Pragmatic Randomized Trial. Ann Intern Med 2014;161:161–9.

[43] Dean BJF, Franklin SL, Murphy RJ, Javaid MK, Carr AJ. Glucocorticoids induce specific ion-channel-mediated toxicity in human rotator cuff tendon: a mechanism underpinning the ultimately deleterious effect of steroid injection in tendinopathy? Br J Sports Med 2014;48:1620–6. doi:10.1136/bjsports-2013-093178.

[44] Coombes B, Bisset L, Brooks P, Khan A, Vicenzino B. Effect of corticosteroid injection, physiotherapy or both on clinical outcomes in patients with unilateral lateral epicondylalgia: a randomized controlled trial. J Am Med Assoc 2013;309:461–9.

[45] Beard DJ, Rees JL, Cook JA, Rombach I, Cooper C, Merritt N, et al. Arthroscopic subacromial decompression for subacromial shoulder pain (CSAW): a multicentre, pragmatic, parallel group, placebo-controlled, three-group, randomised surgical trial. Lancet 2017;6736:1–10. doi:10.1016/S0140-6736(17)32457-1.

[46] Saltychev M, Aarimaa V, Virolainen P, Laimi K. Conservative treatment or surgery for shoulder impingement: systematic review and meta-analysis. Disabil Rehabil 2015;37:1–8.