UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE

PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA

TESE DE DOUTORADO

Dor no ombro: paradoxo entre o modelo patoanatômico e medidas clínicas

Rodrigo Py Gonçalves Barreto

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Dor no ombro: paradoxo entre o modelo patoanatômico e medidas clínicas

Tese de doutorado apresentada ao Programa de Pós-Graduação em Fisioterapia da Universidade Federal de São Carlos como parte dos requisitos para obtenção do título de Doutor em Fisioterapia.

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"The more we learn about the world, and the deeper our learning, the more conscious, specific, and articulate will be our knowledge of what we do not know; our knowledge of our ignorance. For this indeed, is the main source of our ignorance - the fact that our knowledge can be only finite, while our ignorance must necessarily be infinite."

(Karl Popper)

RESUMO

Introdução: A avaliação de pacientes com dor no ombro é altamente influenciada por fatores patoanatômicos. É comum a utilização de testes especiais ou de exames de imagem para a tomada de decisão clínica. Porém, esse modelo tem sido questionado por alguns estudos que sugerem avaliações baseadas em mecanismos diversos para o surgimento da dor como de alteração de movimento e aspectos psicossociais. **Objetivos**: Verificar a associação de fatores patoanatômicos com a apresentação de sintomas e determinar se fatores patoanatômicos contribuem para avaliação da função do ombro. **Métodos**: Ressonância nuclear magnética foi utilizada para avaliação detalhada de alterações patoanatômicas em indivíduos com dor unilateral de ombro. Cortes nos planos coronal, sagital e axial em sequências T1 e T2 foram produzidas e interpretadas de forma independente por um cirurgião ortopédico especializado em cirurgia de ombro e um radiologista especialista em ressonância com ênfase em musculoesquelética. As frequências de alterações patoanatômicas em ambos os ombros foram comparadas e a concordância entre os avaliadores foi avaliada. Para determinar se os fatores patoanatômicos contribuíram para a avaliação da função do ombro, um modelo multivariado utilizando a pontuação total do *Disabilities of the Arm, Shoulder, and Hand* (DASH) como variável dependente foi criado. Variáveis clínicas e demográficas, catastrofização da dor e testes especiais foram utilizados como variáveis explanatórias. **Resultados**: Ambos os ombros apresentaram alta prevalência de alterações patoanatômicas. Ombros sintomáticos apresentaram maior frequência de rupturas totais do manguito rotador e artrose glenoumeral. As demais alterações patoanatômicas observadas não demonstraram diferença estatisticamente significante entre os ombros. Variáveis patoanatômicas não contribuíram com o modelo multivariado. O conjunto de variáveis que melhor explicaram a função do ombro foram a intensidade da dor em repouso, nível de catastrofização e presença de dor à palpação na acromioclavicular. **Conclusões**: Rupturas totais de manguito rotador e presença de osteoartrose glenoumeral parecem ser as únicas alterações patoanatômicas associadas aos sintomas. Níveis elevados de catastrofização e dor em repouso assim como teste de cisalhamento da acromioclavicular positivo foram as melhores variáveis explanatórias para redução de função do ombro. Profissionais da saúde devem estar cientes que a maioria das alterações patoanatômicas avaliadas com a ressonância magnética não estão associadas com os sintomas.

Palavras-chave: síndrome do impacto, lesões de manguito rotador, avaliação, Fisioterapia.

ABSTRACT

Introduction: The evaluation of patients with shoulder pain is highly influenced by pathoanatomical factors. Special tests and imaging are commonly used to the clinical decision-making. However, some studies have called this model into question suggesting more diversified evaluation systems such as movement-based and psychosocial aspects. **Objectives:** To verify the association of pathoanatomical factors with the symptom presentation and determine if pathoanatomical factors contribute to the self-reported shoulder function. **Methods**: Magnetic resonance imaging was used to evaluate in detail pathoanatomical abnormalities in individuals with unilateral shoulder pain. Images in the coronal, sagittal, and axial planes were generated and independently interpreted by a board-certified, orthopedic fellowship trained orthopedic shoulder surgeon and a musculoskeletal radiologist. Frequencies of pathoanatomical abnormalities for both shoulders were compared and the agreement across the evaluators was verified. In order to assess if pathoanatomical factors contributed to the self-reported shoulder function, a multivariate model was built considering the total score of the Disabilities of the Arm, Shoulder, and Hand (DASH) as the dependent variable. Clinical, demographics, pain catastrophizing, and special tests were used as explanatory variables. **Results**: Both shoulders presented a high prevalence of pathoanatomical abnormalities. Symptomatic shoulders showed the highest frequency of full-thickness tear and glenohumeral osteoarthrosis. Other observed pathoanatomical abnormalities did not show statistically significant differences between both shoulders. Pathoanatomical variables did not contribute to the multivariate model. The group of variables that best explained the self-reported shoulder function were pain intensity at rest, pain catastrophizing level, and acromioclavicular joint tenderness during palpation. **Conclusions**: Full-thickness rotator cuff tears and the presence of glenohumeral osteoarthrosis seem to be the only pathoanatomical abnormalities associated with the symptoms. Elevated pain catastrophizing levels and pain intensity at rest as well as acromioclavicular joint tenderness were the best explanatory variables to decreased self-reported shoulder function. Health professionals must be aware that most pathoanatomical abnormalities assessed with the magnetic resonance imaging are not related to the symptoms.

Keywords: impingement syndrome, rotator cuff lesions, evaluation, physical therapy.

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PREFÁCIO

O tratamento da dor no ombro tem originado acentuada divergência de opiniões. À semelhança de outras áreas de pesquisa em musculoesquelética, alguns estudos têm defendido de forma mais intensa a característica multifatorial da dor no ombro e a baixa associação entre os sintomas e lesão tecidual ou sua gravidade. Questões igualmente polêmicas relacionadas à relevância clínica da discinese escapular, alterações de movimento e risco de dor no ombro, falta de validade discriminante para testes provocativos e a utilização de manobras modificadoras de sintomas têm disso recentemente discutidos por alguns estudos como alternativas promissoras de avaliação. Todos esses temas e os resultados dos estudos que têm sido realizados nos motivaram a realizar essa tese para que os dados proporcionados por ela pudessem auxiliar nessas respostas, mas, inicialmente, com o foco em duas questões clínicas muito importantes para pacientes com dor no ombro: (1) as lesões teciduais observadas no ombro estão associadas com os sintomas? (2) quais os componentes da avaliação melhor contribuem para explicar a função do ombro?

Essas questões clínicas originaram os estudos que compõem essa tese. O primeiro deles analisou a frequência de alterações bilaterais observadas no exame de ressonância nuclear magnética em 123 indivíduos com dor unilateral do ombro. Quase todas as possíveis alterações de exame de imagem previstas na literatura foram avaliadas em exames sem identificação e sem qualquer informação clínica de forma independente por um radiologista especialista em ressonância magnética e um médico cirurgião especialista em ortopedia e cirurgia de ombro. Por meio dos resultados desse estudo, é possível inferir sobre a relação das alterações patoanatômicas e a presença de dor no ombro, além de discutir questões como concordância e rigor empregado na avaliação dos exames por esses dois profissionais e como essas informações podem impactar o manejo de pacientes com dor no ombro.

No segundo estudo dessa tese, uma extensa avaliação fisioterapêutica em 87 indivíduos com dor unilateral do ombro foi realizada e todos os participantes também foram submetidos ao exame de ressonância nuclear magnética. A avaliação contemplou informações utilizadas comumente na prática clínica, mas não foi limitada a isso. Dados demográficos, função, catastrofização da dor, dor, duração de sintomas, distúrbios do sono, amplitude de movimento, força muscular, testes provocativos e dados dos exames de imagem foram alguns dos componentes incluídos avaliados. Para determinar a contribuição da ressonância magnética na avaliação, criamos e comparamos a performance de dois modelos multivariados cuja única diferença era a inclusão de informações do exame de imagem. Os resultados desse estudo são muito interessantes pois eles podem influenciar diretamente o modo como avaliamos os pacientes com dor no ombro.

Temos mais três manuscritos em preparação que não estão inseridos nessa tese e que utilizaram outros dados coletados durante a execução desse projeto de doutorado. Esses manuscritos estão sendo desenvolvidos em conjunto com três alunos de iniciação científica coorientados por mim e exploram questões relacionadas ao arco de movimento doloroso, catastrofização da dor e alterações da cinemática escapular. Também estou envolvido na coautoria de outros dois manuscritos explorando questões relacionadas a um teste de modificação de sintomas e alterações de cinemática escapular que compõe a dissertação de mestrado de uma colega de laboratório.

Esse projeto de doutorado foi financiado pela CAPES e fez parte de uma chamada para Pesquisador Visitante Especial pelo Ciências sem Fronteiras. O projeto firmou uma parceria entre a Universidade Federal de São Carlos (UFSCar) e a Universidade de Minnesota nos Estados Unidos. A Profa. Paula Ludewig, uma das pesquisadoras mais importantes no mundo sobre o tema dor no ombro, cinemática escapular e biomecânica foi minha supervisora no período de doutorado sanduíche durante 12 meses e se tornou minha coorientadora no projeto de doutorado. Durante o período fora do país, vivenciei uma rotina de trabalho diferente composta por treinamentos de segurança em radiologia e sigilo de informações de saúde, trabalho em laboratório, auxílio nas coletas de dados de um projeto avaliando nadadores e também expandi o meu conhecimento sobre diferentes métodos de avaliação em biomecânica. Também tive a oportunidade de participar como aluno em quatro disciplinas (*Scientific and Professional Presentation, Clinical Biomechanics, Advanced Biomechanics I: Kinematics e Applied Data Acquisition and Processing*), além de um *workshop* sobre metodologia de ensino. Ainda durante esse período, iniciei a escrita de um manuscrito não relacionado à tese e que avalia a capacidade de alguns parâmetros radiológicos reconstruídos em três dimensões para predizer o risco de compressão do manguito rotador pelo arco coracoacromial durante um movimento simulado de elevação do braço.

Durante o período de doutorado também participei de dois congressos importantes da minha área de pesquisa e realizei uma apresentação oral em cada um deles. O primeiro evento foi a 11ª Conferência do *International Shoulder Group* (ISG) que ocorreu em Winterthur, na Suíça. O outro foi o *Combined Sections Meeting* (CSM), um dos maiores congressos exclusivo para Fisioterapeutas no mundo e o maior dos Estados Unidos. Além deles, parte dos resultados de um dos estudos sendo realizado em conjunto com um dos alunos de iniciação científica foi enviado para o Congresso da *World Confederation for Physical Therapy* (WCPT) 2017 que aconteceu na Cidade do Cabo (África do Sul) e apresentado na modalidade pôster pela Profa. Paula Rezende Camargo que recebeu o *early career researcher award* por este trabalho.

De volta ao Brasil, enviamos um resumo para a próxima edição do ISG a ser realizado na Mayo Clinic nos Estados Unidos em Agosto de 2018. Esse resumo foi aprovado na modalidade *podium presentation* e fomos agraciados com o ISG *Travel Award*. Também realizamos a escrita de um capítulo para PROFISIO Programa de Atualização em Fisioterapia Traumato-Ortopédica (Abordagem Fisioterapêutica Baseada nas Alterações de Movimento Escapular Relacionadas à Dor no Ombro). Atualmente, na fase final do doutorado, a maior concentração de minhas atividades é na escrita dos demais manuscritos, coorientação de alunos de iniciação científica, seminários presenciais do laboratório no Brasil e seminários on-line do laboratório dos Estados Unidos. Além dos projetos de pesquisa, faço parte também do projeto de extensão para atendimento a portadores de dor no ombro realizado na Unidade Saúde Escola (USE) da Universidade Federal de São Carlos sob coordenação da Profa. Paula Rezende Camargo.

O doutorado foi um aprendizado imenso pois me proporcionou crescimento pessoal e amadurecimento dos meus objetivos como pesquisador. Os pesquisadores do PPGFT da UFSCar exercem suas atividades com excelência, a infraestrutura da Universidade não deixa nada a desejar em comparação ao laboratório que permaneci nos Estados Unidos e vale salientar que a Universidade de Minnesota está entre as cinco maiores do país. A organização da carga horária destinada à pesquisa e orientação, disponibilidade constante e extrema expertise do orientador, laboratório para trabalho que possibilita a convivência e convida à discussão com os demais colegas, alunos da graduação sempre em busca de oportunidades de iniciação científica e, por fim, o investimento de recursos financeiros em peso para ciência que ocorre no Estado de São Paulo estão entre as características que eu acredito alavancar a ciência no Brasil.

Portanto, o trabalho a ser exposto a seguir composto pelos dois manuscritos citados representa a minha vontade em evoluir e aprender sempre. Eu vejo o trabalho com a ciência possibilitar a construção e discussão de conhecimento avançado sobre um tema específico e a satisfação de um contato prematuro com informações que ainda não estão totalmente difundidas ou que foram superficialmente exploradas. Poder compartilhar esse conhecimento e aprender discutindo reflexões e dúvidas com outros pesquisadores é algo fantástico que o doutorado me ensinou. Eu espero com essa tese poder contribuir com informações relevantes para a ciência e que elas possam ser bem aproveitadas e compreendidas pelo fisioterapeuta clínico.

CONTEXTUALIZAÇÃO

A dor no ombro é altamente prevalente e estima-se que afete até 30% da população em geral (HILL et al., 2010; PICAVET; SCHOUTEN, 2003). O diagnóstico clínico mais frequente é a síndrome do impacto do ombro (TEKAVEC et al., 2012) definida pela compressão e abrasão mecânica dos tendões do manguito rotador, tendão da cabeça longa do bíceps ou bursa subacromial contra a região anteroinferior do acrômio ou ligamento coracoacromial durante a elevação do braço (NEER, 1972). Também está incluído nesse diagnóstico o impacto interno que é representado pela compressão da superfície articular do músculo infraespinal pela glenoide e lábio glenoidal durante abdução e rotação lateral do ombro (WALCH et al., 1992). Embora essa definição tenha sido descrita por Neer em 1972 e complementada por Walch em 1992, ainda hoje esse diagnóstico clínico é amplamente utilizado (BRAMAN et al., 2014).

Atualmente, considera-se que esse rótulo diagnóstico não contribua para a conduta fisioterapêutica de pacientes com dor no ombro uma vez que há inúmeras possibilidades de lesões que são classificadas dentro do mesmo rótulo como bursite, doença do manguito rotador, rupturas tendíneas, lesões de cabo longo do bíceps ou microinstabilidade (COOLS; MICHENER, 2017; LUDEWIG; LAWRENCE; BRAMAN, 2013). Outro fator que é um confundidor na classificação de pacientes com dor no ombro é que os sintomas apresentados durante a avaliação, disfunção de movimento, déficit de força ou achados em exames de imagem são extremamente diferentes entre os pacientes com dor no ombro ou que receberam o diagnóstico de síndrome do impacto (DE WITTE et al., 2016). Há também divergência sobre os achados de imagem e avaliação que melhor representam a patologia ou disfunção do paciente (DE WITTE et al., 2014). Além disso, a interpretação dos achados patoanatômicos presentes nesses exames de imagem pode ser diferente dependendo da formação do profissional. Por exemplo, já foi relatado em estudos anteriores que a concordância entre cirurgiões de ombro e radiologistas para lesões relacionadas à instabilidade glenoumeral ou doença do manguito rotador varia de pobre à moderada (PANDYA et al., 2008; SCHREINEMACHERS et al., 2009; VAN GRINSVEN et al., 2015). Alguns desses estudos sugerem inclusive que cirurgiões de ombro são mais precisos em relação à interpretação do exame de ressonância nuclear magnética (RNM), ao menos para lesões relacionadas à instabilidade glenoumeral (DINTER et al., 2008; PANDYA et al., 2008; VAN GRINSVEN et al., 2015).

Exames de imagem são frequentemente utilizados para complementar informações do exame físico, porém eles não fornecem indícios claros para a explicação do quadro clínico. As alterações patoanatômicas observadas às vezes podem ser achados ocasionais pois já foram reportadas em indivíduos assintomáticos (BRADLEY; TUNG; GREEN, 2005; MINAGAWA et al., 2013). Entretanto, a generalização a partir dos estudos que reportaram alterações patoanatômicas em ombros assintomáticos é questionável. A maioria desses estudos utilizou amostras restritas em termos de idade ou tamanho, priorizou o recrutamento de atletas e realizou somente descrição de alterações patoanatômicas muito específicas. Dessa forma, a utilidade clínica da ressonância pode ser questionada já que embora apresente alta acurácia para identificação de alteração patoanatômica (ROY et al., 2015), a ressonância não consegue diferenciar em quais pacientes essas alterações estão influenciando os sintomas (CHALMERS et al., 2018).

De forma geral, pacientes com dor no ombro são avaliados principalmente por meio de testes provocativos e exames de imagem como a ressonância ou ultrassonografia para a verificação de alterações patoanatômicas (MCFARLAND et al., 2013). Sugere-se que testes provocativos possam reproduzir a dor ou incapacidade apresentada pelo paciente por meio de tensão ou compressão em estruturas subacromiais (MCFARLAND et al., 2013; PAPADONIKOLAKIS et al., 2011). Diversos testes provocativos podem ser empregados na avaliação do paciente e cada um deles é utilizado para avaliar uma estrutura ou mecanismo etiológico em particular como os populares teste de Neer, Hawkins-Keneddy, Yocum e a presença do arco doloroso durante a elevação do braço (PARK et al., 2005). Porém, na maioria das vezes, não há indicação clara da estrutura anatômica que é a fonte de dor no ombro e os testes provocativos sequer tem a habilidade de diferenciá-las, pois a maioria deles é muito sensível e apresenta resultados positivos para mais de uma lesão/disfunção (HANCHARD et al., 2013).

A avaliação de alterações de movimento e sua relação com os sintomas é uma estratégia promissora, especialmente à Fisioterapia (LUDEWIG et al., 2017; SAHRMANN; AZEVEDO; DILLEN, 2017). Alterações de posição e movimento da articulação escapulotorácica já foram relacionadas com diversas patologias de ombro como a síndrome do impacto, instabilidade glenoumeral ou capsulite adesiva (LEFÈVRE-COLAU et al., 2018; LUDEWIG; REYNOLDS, 2009; TIMMONS et al., 2012). As alterações de movimento escapulotorácico mais reportadas são o déficit de inclinação posterior e rotação superior além do excesso de rotação interna durante a elevação do membro superior. Essas alterações de movimento podem ser observadas e descritas clinicamente como discinese escapulotorácica (KIBLER et al., 2013; LUDEWIG; REYNOLDS, 2009). Porém, outras alterações como o aumento de rotação superior da escápula em indivíduos com ruptura de manguito rotador também já foi relatado (KOLK et al., 2016; MELL et al., 2005; MIURA et al., 2017; SCIBEK; CARPENTER; HUGHES, 2009). Essas alterações podem estar associadas com perda de extensibilidade, atrasos ou incoordenação muscular, principalmente de trapézio inferior, médio ou serrátil anterior (PHADKE; CAMARGO; LUDEWIG, 2009). Entretanto, ainda faltam informações objetivas e mais detalhadas sobre como as alterações patoanatômicas estão associadas com as mais variadas disfunções de movimento e os sintomas (KIBLER et al., 2013; MICHENER; MCCLURE; KARDUNA, 2003).

A imprecisão para a determinação dos fatores mais relacionados aos sintomas reforça a necessidade de avaliações que levem em consideração diversos mecanismos etiológicos para o melhor direcionamento do tratamento como os fatores psicossociais (CHIMENTI; FREY-LAW; SLUKA, 2018). Alguns estudos constataram a influência negativa da catastrofização da dor na função do ombro (CORONADO et al., 2017; GEORGE et al., 2015) e intensidade dos sintomas (GEORGE et al., 2014). Entretanto, outros estudos reportaram fraca ou inexistente associação da catastrofização com função do ombro ou risco de persistência dos sintomas (KROMER et al., 2014; KUIJPERS et al., 2006).

Diante desse contexto, parece que a interpretação do que está realmente associado à apresentação clínica ou quais fatores priorizar na avaliação e tratamento fisioterapêutico em pacientes com dor no ombro não é totalmente claro.

Apesar de todas as informações discutidas anteriormente, ainda há forte influência de fatores patoanatômicos na tomada de decisão clínica. Diversos estudos têm sugerido a priorização de desfechos mais clínicos ou baseados na análise do movimento para avaliar pacientes com dor no ombro já que podem ser mais relacionados com a queixa principal do paciente e representam um conjunto de informações mais prática para o contexto clínico (KELLEY et al., 2013; LUDEWIG et al., 2017; MCCLURE; MICHENER, 2015; SAHRMANN; AZEVEDO; DILLEN, 2017). Porém, são necessários estudos que testem como esses potenciais influenciadores da função do ombro estão relacionados e o quanto eles podem de fato contribuir para a avaliação fisioterapêutica.

OBJETIVOS

Os objetivos dessa tese foram:

1) Determinar e comparar a frequência de alterações patoanatômicas bilaterais em indivíduos com dor unilateral de ombro;
2) Determinar a concordância entre um cirurgião ortopédico especializado em ombro e um radiologista especializado em ressonância magnética para os achados patoanatômicos observados;
3) Determinar o melhor conjunto de variáveis que possam explicar a função do ombro;
4) Avaliar se a adição de informações patoanatômicas melhora a capacidade de explicação da função do ombro.

HIPÓTESES

As hipóteses dessa tese foram:

1) Os dois ombros apresentariam frequência elevada de alterações patoanatômicas;
2) Os dois avaliadores apresentariam concordância substancial em relação à identificação das alterações patoanatômicas;
3) Variáveis clínicas fariam parte do grupo de variáveis que melhor explicaram a função do ombro;
4) A adição de informações patoanatômicas não melhoraria a capacidade de explicação da função do ombro.

MANUSCRITO I

Bilateral Magnetic Resonance Imaging Findings in Individuals with Unilateral Shoulder Pain

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ABSTRACT

Introduction: Magnetic resonance imaging (MRI) is commonly used to diagnose structural abnormalities in the shoulder. However, subsequent findings may not be the source of patient symptoms. The aim of this study was to determine comparative MRI findings across both shoulders of individuals with unilateral shoulder symptoms.

Methods: We prospectively evaluated 123 individuals with self-reported unilateral shoulder pain with no signs of adhesive capsulitis, substantial range of motion deficit, history of upper limb fractures, repeated shoulder dislocations, or neck-related pain. Images in coronal, sagittal, and axial planes with T1, T2, and proton-density sequences were generated and independently interpreted by two examiners, a board-certified, fellowship trained orthopaedic shoulder surgeon and a musculoskeletal radiologist. Absolute and relative frequencies for each MRI finding were calculated and compared between symptomatic and asymptomatic shoulders. Agreement between the shoulder surgeon and the radiologist was also determined.

Results: Abnormal MRI findings were highly prevalent in both shoulders. Only the frequencies of full-thickness tears in the supraspinatus tendon and glenohumeral osteoarthritis were higher (~10%) in the symptomatic shoulder according to the surgeon’s findings. Agreement between the musculoskeletal radiologist and shoulder surgeon ranged from slight to moderate (0.00 to 0.51).

Conclusion: Most of abnormal MRI findings were not different in frequency between symptomatic and asymptomatic shoulders. Clinicians should be aware of the common anatomic findings in MRI when considering diagnostic and treatment planning.

Keywords: clinical decision-making, pathoanatomical model, rehabilitation, scapula.

What are the new findings?

- We provided a detailed bilateral description of image findings observed in individuals with unilateral shoulder pain.
- Only rotator cuff full-thickness tearing and glenohumeral osteoarthritis were more prevalent in the symptomatic shoulder.
- Shoulder surgeon and musculoskeletal radiologist have different interpretation of the same image findings and that may be related to background differences during the professional development.

How might it impact on clinical practice in the future?

- Information about the pathoanatomy prevalence in individuals with unilateral shoulder pain may help clinicians to better interpret when such findings are more likely related to symptoms.
- Clinicians should be aware that the pathoanatomic model has limited ability to direct conservative intervention, and surgery is may be indicated when function loss is observed rather than based on presence of pathoanatomic findings on MRI.
- The results of this study call the pathoanatomical model into question and encourage a more comprehensive rationale to support the clinical decision-making.

INTRODUCTION

Shoulder pain is highly prevalent in individuals seeking health care.[1–3] The pathoanatomical model, whereby the clinician identifies a specific tissue pathology and presumes that to be the source of pain, is predominant in the process to diagnose and guide the treatment for shoulder pain by different professionals.[4–8] As such, during diagnosis, magnetic resonance imaging (MRI) is commonly used to identify structural abnormalities in the shoulder. MRI allows high-resolution imaging of soft tissues and presents high sensitivity and diagnostic accuracy for detecting structural alterations.[9–11] However, some are calling the pathoanatomic diagnostic model into question due to poor association between pathoanatomical findings and symptoms in individuals with painful shoulders.[12–15]

Previous studies have shown bilateral alterations in the MRI findings in individuals with unilateral symptoms[16–20] and in asymptomatic individuals.[16–33] These results suggest that many findings may be incidental and not the cause of symptoms. However, the prevalence of alterations in the MRI findings cannot be extrapolated to the general population with shoulder pain because most investigations assessed only athletes[24,25] or small/age-restricted samples.[19,21,24,25,27,31]

A more comprehensive description of the alterations found in individuals with shoulder pain would be an important addition to the literature as previous focus is mostly given to partial- and full-thickness tears of the supraspinatus (SST) and infraspinatus (IST) tendons.[16–18,20,21,23,25,27,28,30–32] Furthermore, description of bilateral pathoanatomical findings from a substantive representative sample of unilaterally involved individuals can help clinicians interpret clinical utility of the MRI. This is important because of growing concerns with overuse of MRI and a need to avoid unnecessary costs in health care provision.[34–36]

The primary objective of this study was to determine and compare the frequency of tissue pathology bilaterally in individuals with unilateral shoulder pain. The secondary objective was to determine the agreement for the MRI findings between a board-certified, fellowship trained shoulder surgeon and a radiologist. Our hypotheses were that 1) both shoulders would present a high prevalence of alterations, and 2) substantial agreement would occur between the shoulder surgeon and radiologist.

METHODS

Participants and eligibility criteria

An observational study was conducted recruiting patients from the community with self-reported unilateral shoulder pain. The study followed the recommendations of the Helsinki Statement and was approved by the Institutional Review Board of the proponent University. All individuals who agreed to participate signed an informed consent.

One hundred twenty-three individuals (246 shoulders) with chronic intermittent unilateral shoulder pain for 35.8 months on average (SD 58.5, range 1-360 months) since first onset participated in this study. Average age of the participants was 39.4 years (SD 15.23; range 18-77) and 66 were men. The recruitment was performed by advertisements on local websites and printed flyers in the University and community. Individuals with self-reported unilateral shoulder pain for at least four weeks since first onset and full-active arm elevation (~150° or greater) evaluated by digital inclinometer[37] were included in the study. Participants with bilateral complaints, history of previous fractures or surgery in the upper limbs, metallic implants in the trunk, arms, or head, vascular clips, shoulder dislocation within the last 2 years, clinical signs of adhesive capsulitis based on deficit of glenohumeral internal and external rotation,[38] self-reported neck pain, or neck-related symptoms based on a positive Spurling's test were excluded. Eligibility criteria were determined by one of two physical therapists with at least three years of clinical experience related to musculoskeletal disorders.

MRI assessment

All participants underwent a standardized protocol using a Magnetom Essenza, Siemens® MRI machine with a field strength of 1.5 Tesla, field of view of 18 cm and dedicated shoulder array coil for high-resolution, motion-free images. Images with slice thickness of 3.5 to 4.0 millimeters through spin echo sequences in T1, T2, and proton density (PD), as well as gradient echo sequence in T2 were performed for both symptomatic and asymptomatic shoulders. All scans included slices in sagittal, coronal and axial planes without contrast. The participants were positioned in supine with the head toward the scanner bore, arms resting at the side of the body and humerus in neutral or slight external rotation. Anonymized images were independently read by a board-certified orthopedic surgeon with 12 years of shoulder specialized experience after fellowship training, and a radiologist. All data provided by the radiologist were manually retrieved from the clinical report. The radiologist read all scans according to his standard clinical practice, while the shoulder surgeon followed a structured online-based form to ensure a comprehensive analysis.

MRI definitions

The MRI findings were comprehensively assessed as follows: rotator cuff tendinopathy was identified as a thickened tendon with hyperintense signal alteration predominantly in a T1 or PD -weighted fast spin echo sequence, or an increased signal intensity in T2 images, or high signal on PD which does not become as high as the fluid signal on T2. The identification of a focal or diffuse region of intrasubstance intermediate signal on T1 images that persisted on T2 images with or without increased thickness was also diagnosed as tendinopathy.[39–41]

Partial-thickness tearing was observed by the presence of tendon discontinuity along its superior (bursal) or inferior (articular) surface with an extra articular fluid-filled gap on T2 images. Full-thickness tear was differentiated from partial-thickness tear by the presence of discontinuity of the tendon with a fluid-filled gap that extended from the articular to the bursal surface observed mainly on T2 images.[40,41] Musculotendinous retraction was defined as present when the musculotendinous junction was located more medial than its usual footprint location. The extension of musculotendinous retraction was classified as stage 1 (proximal end close to the bony insertion), stage 2 (proximal end at the level of the humeral head), and stage 3 (proximal end at the level of the glenoid).[42]

Fatty infiltration was classified in four stages: stage 1 (muscle with some fatty streaks), stage 2 (increased fatty infiltration but more healthy muscle than fat), stage 3 (fatty infiltration with as much fatty tissue as healthy muscle), stage 4 (more fatty tissue than healthy muscle).[43] SST atrophy was identified by the presence of a tangent sign.[40,41,44,45]

A labrum lesion was identified by a hyperintense signal within the labrum or a morphological irregularity. Anatomical variations such as sublabral foramen or Buford complex were not considered lesions. Superior Labrum Anterior to Posterior (SLAP) lesions were defined as a superior labral lesion with anterior and posterior extension, including the origin of the long head of the biceps tendon.[41,46,47]

Long head of the biceps tendinopathy was diagnosed by the observation of a thickened tendon on PD, T1 images or hyperintense intratendinous signal without signal alterations in T2 images. A partial biceps tear was defined as a T2 hyperintense or T1 hypointense signal alteration. A full-thickness biceps tear was defined by tendon retraction and its absence in the bicipital groove (extra-articular part) observed on axial T2 images and absence of the tendon intra-articular on the oblique sagittal plane.[41,46,48]

Acromioclavicular (AC) joint alterations such as osteoarthritis or joint hypertrophy were observed in the coronal oblique and sagittal oblique planes. Cysts and fluid at the AC joint were observed on T2 images. Tissue proliferation such as osteophytes, joint space narrowing, margin irregularity, and bone sclerosis were identified on T1 images.[49,50]

Glenohumeral osteoarthritis was identified based on findings such as joint narrowing, subchondral sclerosis, osteophyte formation, subchondral cysts, posterior glenoid wear, hypointense glenoid sclerosis, or chondral erosion. These lesions are typically found as hyperintense signals in T2 or axial PD images.[41,49,51]

Glenohumeral synovitis was identified by the presence of high intense signal in the capsule on T2 or PD images in coronal and axial planes. Adhesive capsulitis was identified by the presence of evident synovitis and axillary recess reduction observed in the coronal plane on T2 images.[51] Proximal humeral alterations such as cysts were described by the presence of high intensity and well-demarcated rounded or ovoid points visualized in two planes on T2 images.[52] Increased subacromial fluid was reported when the subacromial bursa contained signal intensity equal to the signal of joint fluid or water on T2 images.[42,46,47] Acromion morphology was described following Epstein's classification,[53,54] divided into three types: type I or flat, type II or smoothly curved, and type III or hooked.

Statistical Analysis

All analyses were performed with IBM SPSS Statistics, version 23 (IBM Corp., Armonk, NY). Chi-square test for independence with Yates' continuity correction was utilized to compare MRI findings from symptomatic and asymptomatic shoulders. Fisher's exact test was used to compare sides when the expected count was less than five. A p-value less than 0.05 was considered statistically significant. Agreement between the findings of the shoulder surgeon and the radiologist was assessed by the total observed agreement and Cohen's Kappa index of agreement.[55] Total observed agreement was defined as the sum of simultaneous positive and negative classifications divided by the number of total observations.[56,57] The level of agreement based on kappa was classified as no agreement (≤ 0), none or slight (0.01 to 0.20), fair (0.21 to 0.40), moderate (0.41 to 0.60), substantial (0.61 to 0.80), and almost perfect (0.81 to 1.00).[55]

The influence of bias and prevalence of answers from both examiners on the kappa index was verified by the bias and prevalence index, respectively. The prevalence index was defined as the difference between the simultaneous positive and negative answers divided by the number of total observations. The bias index was defined as the difference between positive and negative answers from both evaluators divided by the number of total observations.[56,57]

RESULTS

Bilateral prevalence data

MRI alterations were highly observed in all scans in both symptomatic and asymptomatic shoulders (Tables 1-2 and Figure 1). Rotator cuff tendinopathy and alterations in the acromioclavicular were highly prevalent in both shoulders based on the radiologist (~90%) and shoulder surgeon's (~75%) findings. There was no difference in the prevalence of the MRI findings between sides considering the radiologist readings. However, the shoulder surgeon reported higher prevalence of full-thickness tears of the SST tendon and glenohumeral osteoarthritis in the symptomatic shoulders when compared to the asymptomatic ones.

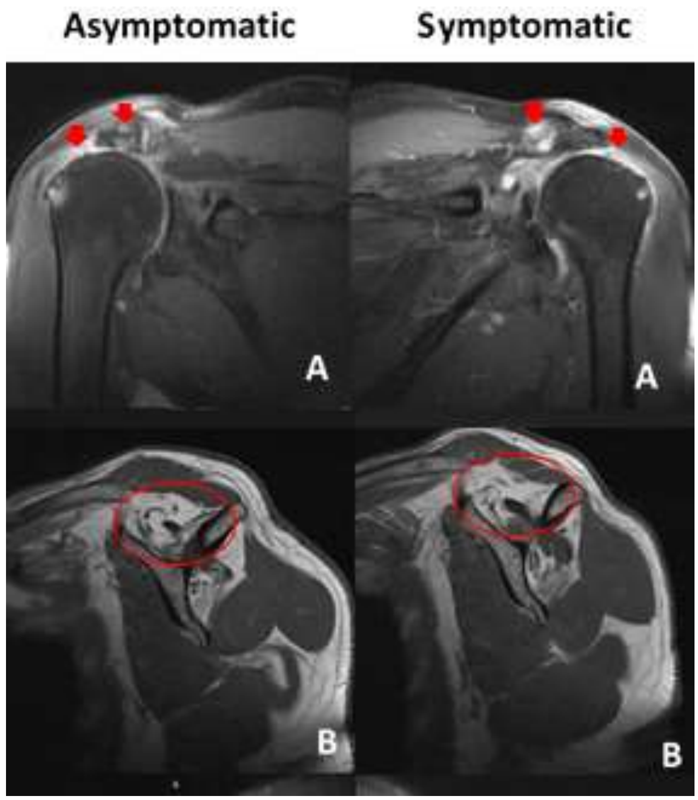

Figure 1: MRI findings of asymptomatic and symptomatic shoulders in a 73-year-old subject. **A** - T2-frontal plane; Arrows show a full-thickness tear of the supraspinatus and acromioclavicular osteoarthritis. **B** - T1-sagittal plane; circle shows fatty degeneration grade IV.

Agreement between examiners

Observed agreement between the radiologist and shoulder surgeon varied from 44.71% to 98.14%. The best observed agreements (~90%) were obtained for SST atrophy, glenohumeral osteoarthritis, and LHB alterations. The best kappa indexes were observed for partial-thickness tears (k= 0.38), LHB alterations (k= 0.44), and cysts in the humeral tuberosities (k= 0.51). The kappa index ranged between 0.00 and 0.51. The percentage of agreement and kappa statistics are provided in Table 3.

Table 1. Prevalence and comparison of the MRI alterations in symptomatic versus asymptomatic shoulders

	Radiologist			Shoulder surgeon		
MRI abnormalities	**Symptomatic shoulder (n=123)**	**Asymptomatic shoulder (n=123)**	**Chi-Square or Fisher's exact test**	**Symptomatic shoulder (n=123)**	**Asymptomatic shoulder (n=123)**	**Chi-Square or Fisher's exact test**
Rotator cuff tendinopathy	114 (92.7%)	109 (88.6%)	X^2= 0.76, p= 0.38	92 (74.8%)	89 (73.0%)	X^2= 0.03, p= 0.85
Partial-thickness tear	33 (26.8%)	25 (20.3%)	X^2= 1.10, p= 0.29	38 (31.1%)	27 (22.0%)	X^2= 2.20, p= 0.13
Full-thickness tear	7 (5.7%)	1 (0.8%)	X^2= 3.23, p= 0.06	25 (20.5%)	10 (8.1%)	X^2= 6.66, p= 0.01*
Subacromial fluid	67 (54.5%)	69 (56.1%)	X^2= 0.00, p= 0.95	75 (61.0%)	65 (52.8%)	X^2= 1.34, p= 0.24
AC alterations	113 (91.9%)	110 (89.4%)	X^2= 0.05, p= 0.80	98 (79.7%)	90 (73.2%)	X^2= 1.10, p= 0.29
Labrum alterations	54 (43.9%)	51 (41.5%)	X^2= 0.09, p= 0.75	81 (66.4%)	82 (67.2%)	X^2= 0.00, p= 1.00
LHB alterations	14 (11.4%)	7 (5.7%)	X^2= 1.82, p= 0.17	16 (13.1%)	15 (12.2%)	X^2= 0.00, p= 0.98
Fatty infiltration	25 (20.3%)	23 (18.7%)	X^2= 0.02, p= 0.87	8 (6.5%)	3 (2.4%)	X^2= 1.52, p= 0.21
SST Atrophy	1 (0.8%)	1 (0.8%)	X^2= 0.00, p= 1.00	4 (3.3%)	1 (0.8%)	X^2= 0.81, p= 0.37
Humeral tuberosity cysts	16 (13.0%)	17 (13.8%)	X^2= 0.00, p= 1.00	29 (23.6%)	23 (18.9%)	X^2= 0.56, p= 0.45
Glenohumeral OA	2 (1.6%)	1 (0.8%)	X^2= 0.00, p= 1.00	13 (10.7%)	4 (3.3%)	X^2= 4.11, p= 0.04*
Acromion morphology						
I	9 (7.3%)	14 (11.4%)	X^2= 0.83, p= 0.36	75 (61.0%)	82 (66.7%)	X^2= 0.63, p= 0.42
II	88 (71.5%)	87 (70.7%)	X^2= 0.00, p= 1.00	29 (23.6%)	25 (20.3%)	X^2= 0.21, p= 0.64
III	15 (12.2%)	14 (11.4%)	X^2= 0.05, p= 0.81	19 (15.4%)	16 (13.0%)	X^2= 0.13, p= 0.71

Abbreviations: AC, acromioclavicular joint abnormalities; LHB, long head of biceps; SST, supraspinatus muscle; OA, osteoarthritis.

*p< 0.05, when both sides were compared.

Table 2. Comparison of the detailed prevalence of the MRI alterations in symptomatic versus asymptomatic shoulders

	Radiologist			**Shoulder surgeon**		
MRI abnormalities	**Symptomatic shoulder (n= 123)**	**Asymptomatic shoulder (n= 123)**	**Chi-Square or Fisher's exact test**	**Symptomatic shoulder (n= 123)**	**Asymptomatic shoulder (n= 123)**	**Chi-Square or Fisher's exact test**
Tendinopathy						
Supraspinatus tendon	109 (88.6%)	107 (87.0%)	X^2= 0.03, p= 0.84	86 (69.9%)	83 (67.5%)	X^2= 0.07, p= 0.78
Infraspinatus tendon	84 (68.3%)	84 (68.3%)	X^2= 0.00, p= 1.00	14 (11.4%)	9 (7.3%)	X^2= 0.76, p= 0.38
Subscapularis tendon	43 (35.0%)	41 (33.3%)	X^2= 0.00, p= 0.93	14 (11.4%)	8 (6.5%)	X^2= 1.24, p= 0.26
Partial-thickness tear						
Supraspinatus tendon	26 (21.1%)	18 (14.6%)	X^2= 1.35, p= 0.24	24 (19.5%)	19 (15.4%)	X^2= 0.45, p= 0.50
Infraspinatus tendon	13 (10.6%)	2 (1.6%)	X^2= 7.10, p< 0.01*	9 (7.3%)	4 (3.3%)	X^2= 1.29, p= 0.25
Subscapularis tendon	13 (10.6%)	14 (11.4%)	X^2= 0.00, p= 1.00	9 (7.3%)	6 (4.9%)	X^2= 0.28, p= 0.59
Full-thickness tear						
Supraspinatus tendon	7 (5.7%)	1 (0.8%)	X^2= 3.23, p= 0.06	20 (16.3%)	4 (3.3%)	X^2= 10.38, p< 0.01*
Infraspinatus tendon	1 (0.8%)	1 (0.8%)	X^2= 0.00, p= 1.00	9 (7.3%)	2 (1.6%)	X^2= 3.42, p= 0.06
Subscapularis tendon	0 (0.0%)	0 (0.0%)	NC	9 (7.3%)	8 (6.5%)	X^2= 0.00, p= 1.00
Retraction						
Supraspinatus tendon	7 (5.7%)	1 (0.8%)	X^2= 3.23, p= 0.07	16 (13.0%)	3 (2.4%)	X^2= 8.21, p< 0.01*
Acromioclavicular joint						
Hypertrophy	101 (82.1%)	99 (80.5)	X^2= 0.02, p= 0.87	25 (20.3%)	21 (17.1%)	X^2= 0.24, p= 0.62
Osteophytes	4 (3.3%)	2 (1.6%)	X^2= 0.17, p= 0.68	44 (35.8%)	41 (33.3%)	X^2= 0.07, p= 0.78
Inflammatory signs	11 (8.9%)	4 (3.3%)	X^2= 2.55, p= 0.11	71 (57.7%)	58 (47.2%)	X^2= 2.34, p= 0.12
Long head of biceps						
Tendinopathy	10 (8.1%)	4 (3.3%)	X^2= 1.89, p= 0.16	9 (7.3%)	9 (7.3%)	X^2= 0.00, p= 1.00
Partial tear	4 (3.3%)	2 (1.6%)	X^2= 0.17, p= 0.68	6 (4.9%)	3 (2.4%)	X^2= 0.46, p= 0.50
Complete tear	1 (0.8%)	0 (0.0%)	X^2= 0.00, p= 1.00	1 (0.8%)	3 (2.4%)	X^2= 0.25, p= 0.62

*p<0.05, when both sides were compared; NC, not computed.

Table 3. Agreement between radiologist and shoulder surgeon

MRI alterations	Prevalence of positive alterations Radiologist / Surgeon	Observed agreement	Kappa	Prevalence index	Bias index
Rotator cuff tendinopathy	90.6% / 73.9%	75.10%	0.18*	0.64	0.16
Partial-thickness tear	23.7% / 26.5%	76.73%	0.38*	0.49	0.02
Full-thickness tear	3.3% / 14.3%	88.97%	0.33*	0.82	0.11
Increased subacromial fluid	59.4% / 58.1%	65.50%	0.28*	0.17	0.01
AC alterations	91.0% / 76.7%	78.36%	0.22*	0.67	0.14
Labral alterations	42.7% / 67.2%	59.75%	0.23*	0.09	0.24
LHB alterations	8.7% / 12.8%	89.25%	0.44*	0.78	0.04
Fatty infiltration	19.5% / 4.5%	84.95%	0.32*	0.76	0.15
SST atrophy	0.9% / 0.9%	98.14%	0.00	0.98	0.00
Humeral tuberosity cysts	13.1% / 21.2%	86.12%	0.51*	0.65	0.08
Glenohumeral OA	1.2% / 6.9%	94.28%	0.28*	0.91	0.05
Acromion morphology					
I	8.5% / 63.8%	44.71%	0.10*	0.27	0.55
II	50.8% / 22.0%	52.43%	0.05	0.27	0.28
III	8.1% / 14.2%	83.33%	0.16*	0.77	0.06

Abbreviations: AC, acromioclavicular joint; LHB, long head of biceps; SST, supraspinatus muscle; OA, osteoarthritis; NS, not statistically significant; *statistically significant Kappa index.

DISCUSSION

This study demonstrated high prevalence of bilateral MRI alterations in individuals with unilateral shoulder pain (**Figure 1**). Few differences between symptomatic and asymptomatic shoulders were observed. This investigation adds to the literature as a substantial number of MRI scans were assessed by two experienced professionals and a more comprehensive description of the MRI alterations is provided. In addition, slight to moderate agreement between examiners was observed. Both of these results cause concern for the utility of MR as the most effective diagnostic tool, except for full thickness tears or OA. Of further relevance, OA can be determined less expensively on radiograph.

Previous investigations have reported alterations in asymptomatic shoulders using ultrasound (US)[16–20,22,26,32,33] and MRI.[21,23,25,27–31] The most common findings included partial and full-thickness tears of the SST and IST tendons with a prevalence ranging from 2 to 95%.[16–18,20,21,23,25–32] These past studies focused on describing alterations only in the SST and IST tendons or presented a grouped prevalence of all rotator cuff tendons, hindering a detailed evaluation of which tendons were affected. In the current study, partial (~21.1%) and full-thickness tear (~4.5%) of the rotator cuff tendons were also identified in asymptomatic shoulders, but relatively infrequently for full-thickness tears. This suggests that well asymptomatic full-thickness tears may occur, symptoms are much more likely to be present if a full-thickness tear is present for supra or infraspinatus. Tables 1 and 2 show that other shoulder joint abnormalities were observed as well.

This investigation questions the clinical diagnostic utility of the MRI since a high prevalence of alterations in asymptomatic shoulders were observed. This indicates that although MRI can accurately identify tissue pathology, it cannot discriminate if that altered anatomy is associated with specific clinical findings. This is of particular importance to physicians, surgeons, and physical therapists who might use the MRI findings to guide the decision toward a treatment plan. Surgeons should be discouraged from deciding on a surgery based only on the MRI findings as patient functionality is the most important factor to be considered in this decision.[58] In addition, patients should be counseled that the alterations found are common and may not be the source of pain. Physical therapists are encouraged to use a pathokinesiologic movement-based or biopsychosocial model to guide diagnosis and treatment planning instead of relying on a pathoanatomic model. The pathoanatomic model has limited ability to direct conservative intervention and most physical therapy treatments have a movement impairment-based approach.[59,60]

According to our results, only the prevalence of full-thickness tear and glenohumeral osteoarthritis presented statistically significant differences between the symptomatic and asymptomatic side. Considering the similar accuracy between US and MRI for detecting full-thickness tears,[9,10] clinicians could consider the use of US as the primary imaging modality when full-thickness tearing is suspected. US examination represents a less expensive and quicker option to determine the presence or absence of full-thickness tears. If US revealed a full-thickness tear, follow-up MRI could be used more judiciously to add additional surgical planning information such as identification of concurrent fatty infiltration, atrophy, or OA. In addition, a better and more detailed evaluation of glenohumeral osteoarthritis could be performed utilizing X-ray or computed tomography in comparison to MRI.[61,62]

Our study also showed a high prevalence of alterations in the AC joint of asymptomatic shoulders (~81%). Other investigations reported a smaller prevalence of AC joint osteoarthritis (~64%) in asymptomatic shoulders.[28–30] These differences may be related to variations in the MRI acquisition protocol such as sequences, field strength, slice thickness, or even coil or dedicated software enhancements brought by advances in technology.[63] Another possible reason to the discrepancy of results may be the small sample size of the previous studies in comparison to ours and the lack of information about the examiners background.

Differences in interpretation between the examiners

In our study, differences in the prevalence of positive MRI alterations between examiners were observed for rotator cuff tendinopathy, AC joint alterations, fatty infiltration, and labral and full-thickness rotator cuff tears. Overall, the radiologist reported more positive MRI alterations than the shoulder surgeon except for labral tears and full-thickness tearing. Additionally, the surgeon noted more humeral cysts and glenohumeral osteoarthritis.

Tendinopathy and full-thickness tear are distinct findings. The former is identified by subtle changes in T2 signal while the latter by marked gapping between the end of the tendon and the humeral attachment on the tuberosity. Because of the high sensitivity and specificity of MRI to detect full-thickness rotator cuff tears, we believe Table 1 and 2 findings suggest a higher level of precision for the surgeon versus the radiologist. The radiologist reading indicated similar frequency of tendinopathy between symptomatic and asymptomatic shoulders and very low frequencies of full-thickness tearing. While the radiologist documented more infraspinatus tendinopathy, the surgeon more frequently identified supraspinatus tendon retraction in the symptomatic shoulder. We believe higher precision for the surgeon may have been due to his subspecialty practice centered on shoulder care and his use of a structured format to evaluate the scans. There are few studies that evaluate agreement of MRI findings between shoulder surgeons and radiologists or compare a structured research evaluation to a routine image reading. Previous investigations have reported agreement between shoulder/orthopedic surgeons and radiologists to range between slight to moderate.[64–67] It is likely that background differences related to the specialty such as fellowship training may influence the MRI reading. In addition, some studies have suggested better accuracy for detecting instability-related lesions such as labrum alterations and SLAP tears by orthopedic surgeons in comparison to radiologists.[64,65,67] Our results seem to support this idea, however, further studies using surgical confirmation as a reference standard are required to confirm this hypothesis.

Limitations

The main limitation of this study is that our imaging captures a single moment in time and therefore cannot assess the risk of symptom development for the asymptomatic shoulder. When interpreting our data, it is important for clinicians to remember that location, size, and tear retraction may play a role in the risk of symptom development and functional decline. Our results suggest that full-thickness tears may be related to the symptoms, but tendinopathy and partial-thickness tearing are not consistently found more commonly in symptomatic shoulders than in those without symptoms. Further studies are necessary to determine how each of those factors contribute to the development of symptoms. Despite that, the current study evaluated MRI alterations in both shoulders for a large sample of individuals with unilateral symptoms and provided prevalence data for all pathologies, which was not available in previous studies.[16–18,20,21,23,25]

CONCLUSIONS

MRI alterations were equally observed in both shoulders of individuals with unilateral symptoms except for full-thickness tears and the presence of glenohumeral osteoarthritis that were mostly seen on the symptomatic side. Slight to moderate agreement was observed between a fellowship trained shoulder surgeon and a radiologist. Clinicians should be aware of the limited enhanced value of MRI in the clinical decision-making process. We encourage that shoulder surgery may be indicated more specifically when function loss is observed rather than based on presence of pathoanatomic findings on MRI.

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REFERENCES

1 Tekavec E, Jöud A, Rittner R, *et al.* Population-based consultation patterns in patients with shoulder pain diagnoses. *BMC Musculoskelet Disord* 2012;13:238. doi:10.1186/1471-2474-13-238

2 Luime J, Koes B, Hendriksen I, *et al.* Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol* 2004;33:73–81. doi:10.1080/03009740310004667

3 Linsell L, Dawson J, Zondervan K, *et al.* Prevalence and incidence of adults consulting for shoulder conditions in UK primary care; patterns of diagnosis and referral. *Rheumatol Oxf Engl* 2006;45:215–21. doi:10.1093/rheumatology/kei139

4 Judge A, Murphy RJ, Maxwell R, *et al.* Temporal trends and geographical variation in the use of subacromial decompression and rotator cuff repair of the shoulder in England. *Bone Joint J* 2014;96:70–74.

5 Vitale MA, Arons RR, Hurwitz S, *et al.* The Rising Incidence of Acromioplasty. *J Bone Joint Surg Am Vol* 2010;92:1842–50. doi:10.2106/JBJS.I.01003

6 de Witte PB, de Groot JH, van Zwet EW, *et al.* Communication breakdown: clinicians disagree on subacromial impingement. *Med Biol Eng Comput* 2014;52:221–31. doi:10.1007/s11517-013-1075-0

7 McFarland EG, Maffulli N, Del Buono A, *et al.* Impingement is not impingement: the case for calling it “Rotator Cuff Disease.” *Muscles Ligaments Tendons J* 2013;3:196–200.

8 Braman JP, Zhao KD, Lawrence RL, *et al.* Shoulder impingement revisited: evolution of diagnostic understanding in orthopedic surgery and physical therapy. *Med Biol Eng Comput* 2014;52:211–9. doi:10.1007/s11517-013-1074-1

9 Roy J-S, Braën C, Leblond J, *et al.* Diagnostic accuracy of ultrasonography, MRI and MR arthrography in the characterisation of rotator cuff disorders: a systematic review and meta-analysis. *Br J Sports Med* 2015;49:1316–28. doi:10.1136/bjsports-2014-094148

10 Ottenheijm RP, Jansen MJ, Staal JB, *et al.* Accuracy of Diagnostic Ultrasound in Patients With Suspected Subacromial Disorders: A Systematic Review and Meta-Analysis. *Arch Phys Med Rehabil* 2010;91:1616–25. doi:10.1016/j.apmr.2010.07.017

11 Lenza M, Buchbinder R, Takwoingi Y, *et al.* Magnetic resonance imaging, magnetic resonance arthrography and ultrasonography for assessing rotator cuff tears in people with shoulder pain for whom surgery is being considered. *Cochrane Database Syst Rev* 2013;:CD009020. doi:10.1002/14651858.CD009020.pub2

12 Dunn WR, Kuhn JE, Sanders R, *et al.* Symptoms of Pain Do Not Correlate with Rotator Cuff Tear Severity: A Cross-Sectional Study of 393 Patients with a Symptomatic Atraumatic Full-Thickness Rotator Cuff Tear. *J Bone Joint Surg Am* 2014;96:793–800. doi:10.2106/JBJS.L.01304

13 Drew BT, Smith TO, Littlewood C, *et al.* Do structural changes (eg, collagen/matrix) explain the response to therapeutic exercises in tendinopathy: a systematic review. *Br J Sports Med* 2014;48:966–72. doi:10.1136/bjsports-2012-091285

14 Russell RD, Knight JR, Mulligan E, *et al.* Structural integrity after rotator cuff repair does not correlate with patient function and pain: a meta-analysis. *J Bone Joint Surg Am* 2014;96:265–71. doi:10.2106/JBJS.M.00265

15 Elliott RSJ, Lim Y-J, Coghlan J, *et al.* Structural integrity of rotator cuff at 16 years following repair: good long-term outcomes despite recurrent tears. *Shoulder Elb* 2017;:1758573217738198. doi:10.1177/1758573217738198

16 Yamamoto A, Takagishi K, Osawa T, *et al.* Prevalence and risk factors of a rotator cuff tear in the general population. *J Shoulder Elbow Surg* 2010;19:116–20. doi:10.1016/j.jse.2009.04.006

17 Minagawa H, Yamamoto N, Abe H, *et al.* Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. *J Orthop* 2013;10:8–12. doi:10.1016/j.jor.2013.01.008

18 Milgrom C, Schaffler M, Gilbert S, *et al.* Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Joint Surg Br* 1995;77:296–8.

19 Tempelhof S, Rupp S, Seil R. Age-related prevalence of rotator cuff tears in asymptomatic shoulders. *J Shoulder Elbow Surg* 1999;8:296–299.

20 Jeong J, Shin D-C, Kim T-H, *et al.* Prevalence of asymptomatic rotator cuff tear and their related factors in the Korean population. *J Shoulder Elbow Surg* 2017;26:30–5. doi:10.1016/j.jse.2016.05.003

21 Chandnani V, Ho C, Gerharter J, *et al.* MR findings in asymptomatic shoulders: a blind analysis using symptomatic shoulders as controls. *Clin Imaging* 1992;16:25–30.

22 Girish G, Lobo LG, Jacobson JA, *et al.* Ultrasound of the shoulder: asymptomatic findings in men. *Am J Roentgenol* 2011;197:W713-719. doi:10.2214/AJR.11.6971

23 Neumann CH, Holt RG, Steinbach LS, *et al.* MR imaging of the shoulder: appearance of the supraspinatus tendon in asymptomatic volunteers. *Am J Roentgenol* 1992;158:1281–7. doi:10.2214/ajr.158.6.1590124

24 Miniaci A, Mascia AT, Salonen DC, *et al.* Magnetic resonance imaging of the shoulder in asymptomatic professional baseball pitchers. *Am J Sports Med* 2002;30:66–73. doi:10.1177/03635465020300012501

25 Connor PM, Banks DM, Tyson AB, *et al.* Magnetic resonance imaging of the asymptomatic shoulder of overhead athletes: a 5-year follow-up study. *Am J Sports Med* 2003;31:724–7. doi:10.1177/03635465030310051501

26 Moosmayer S, Smith H-J, Tariq R, *et al.* Prevalence and characteristics of asymptomatic tears of the rotator cuff: an ultrasonographic and clinical study. *J Bone Joint Surg Br* 2009;91:196–200. doi:10.1302/0301-620X.91B2.21069

27 Schwartzberg R, Reuss BL, Burkhart BG, *et al.* High Prevalence of Superior Labral Tears Diagnosed by MRI in Middle-Aged Patients With Asymptomatic Shoulders. *Orthop J Sports Med* 2016;4:2325967115623212. doi:10.1177/2325967115623212

28 Liou JT, Wilson AJ, Totty WG, *et al.* The normal shoulder: common variations that simulate pathologic conditions at MR imaging. *Radiology* 1993;186:435–41. doi:10.1148/radiology.186.2.8421747

29 Sher JS, Uribe JW, Posada A, *et al.* Abnormal findings on magnetic resonance images of asymptomatic shoulders. *J Bone Joint Surg Am* 1995;77:10–5.

30 Needell SD, Zlatkin MB, Sher JS, *et al.* MR imaging of the rotator cuff: peritendinous and bone abnormalities in an asymptomatic population. *Am J Roentgenol* 1996;166:863–7. doi:10.2214/ajr.166.4.8610564

31 Frost P, Andersen JH, Lundorf E. Is supraspinatus pathology as defined by magnetic resonance imaging associated with clinical sign of shoulder impingement? *J Shoulder Elbow Surg* 1999;8:565–8. doi:10.1016/S1058-2746(99)90090-3

32 Yamaguchi K, Tetro AM, Blam O, *et al.* Natural history of asymptomatic rotator cuff tears: a longitudinal analysis of asymptomatic tears detected sonographically. *J Shoulder Elbow Surg* 2001;10:199–203. doi:10.1067/mse.2001.113086

33 Schibany N, Zehetgruber H, Kainberger F, *et al.* Rotator cuff tears in asymptomatic individuals: a clinical and ultrasonographic screening study. *Eur J Radiol* 2004;51:263–8. doi:10.1016/S0720-048X(03)00159-1

34 Hendee WR, Becker GJ, Borgstede JP, *et al.* Addressing overutilization in medical imaging. *Radiology* 2010;257:240–5. doi:10.1148/radiol.10100063

35 Colla CH, Kinsella EA, Morden NE, *et al.* Physician perceptions of Choosing Wisely and drivers of overuse. *Am J Manag Care* 2016;22:337–43.

36 Bradley MP, Tung G, Green A. Overutilization of shoulder magnetic resonance imaging as a diagnostic screening tool in patients with chronic shoulder pain. *J Shoulder Elbow Surg* 2005;14:233–7. doi:10.1016/j.jse.2004.08.002

37 Camargo PR, Phadke V, Zanca GG, *et al.* Concurrent validity of inclinometer measures of scapular and clavicular positions in arm elevation. *Physiother Theory Pract* 2018;34:121–30. doi:10.1080/09593985.2017.1370753

38 Kelley MJ, Shaffer MA, Kuhn JE, *et al.* Shoulder pain and mobility deficits: adhesive capsulitis. *J Orthop Sports Phys Ther* 2013;43:A1-31. doi:10.2519/jospt.2013.0302

39 Opsha O, Malik A, Baltazar R, *et al.* MRI of the rotator cuff and internal derangement. *Eur J Radiol* 2008;68:36–56. doi:10.1016/j.ejrad.2008.02.018

40 Kassarjian A, Bencardino JT, Palmer WE. MR Imaging of the Rotator Cuff. *Radiol Clin North Am* 2006;44:503–23. doi:10.1016/j.rcl.2006.04.005

41 Farshad-Amacker NA, Jain Palrecha S, Farshad M. The Primer for Sports Medicine Professionals on Imaging. *Sports Health* 2013;5:50–77. doi:10.1177/1941738112468265

42 Farley TE, Neumann CH, Steinbach LS, *et al.* Full-thickness tears of the rotator cuff of the shoulder: diagnosis with MR imaging. *Am J Roentgenol* 1992;158:347–51. doi:10.2214/ajr.158.2.1729796

43 Fuchs B, Weishaupt D, Zanetti M, *et al.* Fatty degeneration of the muscles of the rotator cuff: Assessment by computed tomography versus magnetic resonance imaging. *J Shoulder Elbow Surg* 1999;8:599–605. doi:10.1016/S1058-2746(99)90097-6

44 Gladstone JN, Bishop JY, Lo IKY, *et al.* Fatty infiltration and atrophy of the rotator cuff do not improve after rotator cuff repair and correlate with poor functional outcome. *Am J Sports Med* 2007;35:719–28. doi:10.1177/0363546506297539

45 Kissenberth MJ, Rulewicz GJ, Hamilton SC, *et al.* A positive tangent sign predicts the repairability of rotator cuff tears. *J Shoulder Elbow Surg* 2014;23:1023–7. doi:10.1016/j.jse.2014.02.014

46 Feller JF, Tirman PF, Steinbach LS, *et al.* Magnetic resonance imaging of the shoulder: review. *Semin Roentgenol* 1995;30:224–40.

47 Steinbach LS, Gunther SB. Magnetic resonance imaging of the rotator cuff. *Semin Roentgenol* 2000;35:200–16.

48 Morag Y, Bedi A, Jamadar DA. The rotator interval and long head biceps tendon: anatomy, function, pathology, and magnetic resonance imaging. *Magn Reson Imaging Clin N Am* 2012;20:229–59, x. doi:10.1016/j.mric.2012.01.012

49 Vahlensieck M. MRI of the shoulder. *Eur Radiol* 2000;10:242–9. doi:10.1007/s003300050040

50 de Abreu MR, Chung CB, Wesselly M, *et al.* Acromioclavicular joint osteoarthritis: Comparison of findings derived from MR imaging and conventional radiography. *Clin Imaging* 2005;29:273–7. doi:10.1016/j.clinimag.2004.11.021

51 Pedowitz RA, Chung CB, Resnick D, *et al.* *Magnetic resonance imaging in orthopedic sports medicine*. New York, NY: : Springer 2008.

52 Williams M, Lambert RGW, Jhangri GS, *et al.* Humeral head cysts and rotator cuff tears: an MR arthrographic study. *Skeletal Radiol* 2006;35:909–14. doi:10.1007/s00256-006-0157-6

53 Epstein RE, Schweitzer ME, Frieman BG, *et al.* Hooked acromion: prevalence on MR images of painful shoulders. *Radiology* 1993;187:479–81. doi:10.1148/radiology.187.2.8475294

54 Habermeyer P LS Magosch P. Classifications and Scores of the Shoulder. Berlin; New York: : Springer 2006.

55 Cohen J. A coefficient of agreement for nominal scales. *Educ Psychol Meas* 1960;20:37–46.

56 Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. *Phys Ther* 2005;85:257–68.

57 Byrt T, Bishop J, Carlin JB. Bias, prevalence and kappa. *J Clin Epidemiol* 1993;46:423–9.

58 Butler M, Forte M, Braman J, *et al. Nonoperative and Operative Treatments for Rotator Cuff Tears: Future Research Needs: Identification of Future Research Needs From Comparative Effectiveness Review No. 22 [Internet]*. Rockville (MD): : Agency for Healthcare Research and Quality (US) 2013. http://www.ncbi.nlm.nih.gov/books/NBK153178/ (accessed 4 Apr 2018).

59 Ludewig PM, Kamonseki DH, Staker JL, *et al.* Changing our diagnostic paradigm: movement system diagnostic classification. *Int J Sports Phys Ther* 2017;12:884–93.

60 Sahrmann S, Azevedo DC, Dillen LV. Diagnosis and treatment of movement system impairment syndromes. *Braz J Phys Ther* 2017;21:391–9. doi:10.1016/j.bjpt.2017.08.001

61 Lowe JT, Testa EJ, Li X, *et al.* Magnetic resonance imaging is comparable to computed tomography for determination of glenoid version but does not accurately distinguish between Walch B2 and C classifications. *J Shoulder Elbow Surg* 2017;26:669–73. doi:10.1016/j.jse.2016.09.024

62 Sears BW, Johnston PS, Ramsey ML, *et al.* Glenoid bone loss in primary total shoulder arthroplasty: evaluation and management. *J Am Acad Orthop Surg* 2012;20:604–13. doi:10.5435/JAAOS-20-09-604

63 Sobol WT. Recent advances in MRI technology: Implications for image quality and patient safety. *Saudi J Ophthalmol* 2012;26:393–9. doi:10.1016/j.sjopt.2012.07.005

64 Dinter DJ, Martetschläger F, Büsing KA, *et al.* [Shoulder injuries in overhead athletes: utility of MR arthrography]. *Sportverletz Sportschaden Organ Ges Orthopadisch-Traumatol Sportmed* 2008;22:146–52. doi:10.1055/s-2008-1027747

65 Pandya NK, Colton A, Webner D, *et al.* Physical examination and magnetic resonance imaging in the diagnosis of superior labrum anterior-posterior lesions of the shoulder: a sensitivity analysis. *Arthroscopy* 2008;24:311–7. doi:10.1016/j.arthro.2007.09.004

66 Schreinemachers SA, van der Hulst VPM, Willems WJ, *et al.* Detection of partial-thickness supraspinatus tendon tears: is a single direct MR arthrography series in ABER position as accurate as conventional MR arthrography? *Skeletal Radiol* 2009;38:967–75. doi:10.1007/s00256-009-0680-3

67 van Grinsven S, Nijenhuis TA, Konings PC, *et al.* Are radiologists superior to orthopaedic surgeons in diagnosing instability-related shoulder lesions on magnetic resonance arthrography? A multicenter reproducibility and accuracy study. *J Shoulder Elbow Surg* 2015;24:1405–12. doi:10.1016/j.jse.2015.05.050

MANUSCRITO II

To what extent do components of the clinical evaluation relate to function of the upper extremity?

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ABSTRACT

Background: Physical exam, self-reported measures, and imaging findings are commonly assessed in individuals with shoulder pain. However, it is not well known how much various measures relate to self-reported function.

Objective: To determine the relationship between different evaluation measures and self-reported upper extremity function.

Design: Cross-sectional study.

Methods: Eighty-one individuals with unilateral shoulder pain for at least four weeks and meeting clinical exam criteria to exclude cervical referred pain and adhesive capsulitis, participated in this study. Shoulder range of motion, muscle strength, pain intensity, subject demographics, pain catastrophizing, overhead sports or work exposure, special tests were assessed as related variables in a multivariable model with the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire as the outcome variable. A second model tested the addition of a magnetic resonance imaging variable.

Results: The first model explained 64.6% of the DASH variance compared to 64.2% for the second model, which added the most highly correlated imaging finding to the analysis. Pain catastrophizing and pain intensity were the strongest explanatory variables in both models, explaining ~15% and 6.76% of the DASH variance, respectively.

Limitations: Additional variables in the model, such as self-efficacy, education level, or depression, might have explained further variance in the DASH. Furthermore, not all possible clinical variables were evaluated in the model.

Conclusions: Pain catastrophizing and pain intensity were the components of the clinical evaluation that demonstrated highest relationship to self-reported upper extremity function in this analysis. Physical measures did not independently contribute significantly to the final model, although they were also associated with the DASH score. Most imaging data did not show strong relationship to the DASH score.

INTRODUCTION

Shoulder pain is the second most frequent musculoskeletal complaint in the clinical setting with a lifetime prevalence up to 67%.[1,2] Patients complaining about their shoulders are commonly assessed using imaging and patient self-reported measures such as pain intensity, function, and duration of symptoms.[3,4] Muscle strength and range of motion are also standard as part of the physical examination measures.[3,4] Physical measures are related to shoulder function and represent a low cost in comparison to imaging modalities as the magnetic resonance imaging (MRI), for example.[5–9] The extent of contribution to shoulder function provided by each of those evaluation measures is not well known. No past investigations have comprehensively considered measures of pain in combination with other clinical examination and imaging findings in relation to upper extremity function.

A systematic review suggested that patients with high levels of self-reported pain are between 10% to 210% more likely to have a poor outcome when compared with patients with less pain.[8] This variability is related to wide confidence intervals across the studies suggesting that a more complex multifactorial process is at play. Other aspects related to self-reported pain have been shown to relate to shoulder function such as pain catastrophizing.[7] Pain catastrophizing is a set of negative and exaggerated cognitive and emotional schema in response to an actual or potential pain experience.[10] Few studies have assessed if it relates to self-reported shoulder function.[11–13] A recent investigation reported that pain catastrophizing combined with fear-avoidance, when the patient avoids activities on the basis of fear, explained up to 28% of shoulder function.[11] However, other studies reported low (9%)[12] or nearly no contribution[13] of pain catastrophizing to self-reported shoulder function as measured with the Shoulder Pain and Disabilities (SPADI) score.

With regard to imaging findings, large rotator cuff tears were shown to relate to lesser shoulder function as measured with the Constant-Murley score (CMS) but some assessment questionnaires may overemphasize physical measures such as muscle strength or range of motion in the final score, thus even patients with slight physical deficits related to the cuff tear may exhibit low function scores.[14] A systematic review[8] identified studies describing no association between muscle strength[15] or range of motion[16,17] and shoulder function while other studies have found the opposite but with varying degrees of relationship.[17–21] Although the relationship between physical measures and self-reported shoulder function has been previously supported,[5–9,22] it is not uncommon to observe collapsed or categorized continuous variables, which decrease statistical performance and accuracy.[23,24] There is still a need for better understanding of how a patient's history, clinical examination and imaging findings relate to the self-reported upper extremity function. Therefore, the objective of this study was to determine the association between examination findings and self-reported upper extremity function as measured by the DASH score. Our hypothesis was that physical measures would be associated with the DASH score and that adding imaging information would not improve the overall relationship between examination findings and self-reported function.

METHODS

Study design

We performed a cross-sectional cohort study of patients with self-reported unilateral shoulder pain to determine relationships between clinical examination findings and self-reported function. The independent variables chosen were judged as clinically important variables from the literature.[8,18,22,25–27] A broad set of pathoanatomic variables that are ordinarily assessed in the clinical setting by MRI were also considered.

Participants

Participants were recruited using posts on local websites and printed flyers at the university and in the surrounding community. All participants had to have self-reported unilateral shoulder pain for at least four weeks since first onset to be eligible. Individuals with bilateral shoulder pain, history of upper limb fractures or surgery, metallic implants in the head, thorax or arms, shoulder dislocation within two years or history of recurrent shoulder dislocations, clinical signs of adhesive capsulitis as assessed by glenohumeral external and internal rotation deficit,[28] self-reported neck pain, fibromyalgia, or positive Spurling's test or Upper Limb Tension test exacerbating the reported symptoms were excluded from the study.[29] All individuals were evaluated by one physical therapist with five years of clinical experience in treating patients with musculoskeletal disorders. This study was approved by the institutional review board of the University and all individuals signed a written consent form before study enrollment.

Self-reported upper extremity function

Self-reported upper extremity function was evaluated using the Brazilian version of the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) which was considered the primary outcome measure. The DASH is a self-reported questionnaire with 30 questions that assess the individual's ability to perform several daily living activities. Scores on the DASH can range from 0 to 100 with 0 as the best and 100 as the worst possible scores.[30] The DASH is widely used to assess individuals with shoulder pain[31–33] and demonstrates excellent reliability (average intraclass correlation coefficient of 0.90) and responsiveness (average standard error of the measurement and standardized response mean of 4.5 and 1.4, respectively).[34] In addition, the DASH encompasses a wide range of body functions and activities which makes the content being evaluated by this instrument linked to International Classification of Functioning, Disability and Health categories in comparison to other common self-reported or composite patient-reported outcome measurements.[35]

Range of motion

Active range of motion (ROM) of shoulder flexion (**Figure 1**), abduction (**Figure 2**), external (**Figure 3**) and internal rotation (**Figure 4**) were evaluated with a digital inclinometer (Acumar, Lafayette®). Shoulder flexion and abduction were evaluated in the standing position with full elbow extension, and the inclinometer was placed distally on the humeral shaft. Individuals were instructed to assume a relaxed resting position with the tested arm at the side of the body, and then were asked to raise the arm until the maximum ROM. Shoulder external and internal rotation were evaluated in the supine position with the inclinometer aligned over the mid-forearm, shoulder and elbow at 90º of abduction and flexion, respectively. Individuals were asked to perform each movement until the maximum ROM. During the internal rotation measurement, one hand of the physical therapist provided stabilization to the scapula. The average of two repetitions for each movement was calculated.

Figure 1: Assessment of active range of motion of shoulder flexion.

Figure 2: Assessment of active range of motion of shoulder abduction.

Figure 3: Assessment of active range of motion of shoulder external rotation.

Figure 4: Assessment of active range of motion of shoulder internal rotation.

Muscle force production

The serratus anterior test was performed with the individuals in supine and elbow and shoulder flexed at 90°.[36] The dynamometer was placed on the elbow with the force being applied to the ulna perpendicular to the treatment table. Individuals were instructed to protract their shoulder against the dynamometer. The lower trapezius test was assessed with the individuals in prone with full elbow extension and the shoulder abducted to 140°. Individuals were positioned and instructed to move their scapula in the direction of the opposite hip while the examiner applied force to the midpoint between the acromion and the root of the scapular spine parallel to the long axis of the humerus.[36] The infraspinatus test was assessed with the individuals in supine, the arm at the side of the body and the elbow flexed to 90°. The dynamometer was placed 2 cm proximal to the styloid process of the ulna on the dorsal side of the forearm.[37] Individuals were instructed to externally rotate their shoulder against the dynamometer. For familiarization, individuals performed 1 submaximal repetition of each test prior to data collection. The average of three 5-second repetitions of maximum isometric contraction for each test was calculated and normalized using body mass.[38] The principal investigator gave standardized verbal encouragement to all individuals during the muscle testing to facilitate maximal force production (**Figure 5**).

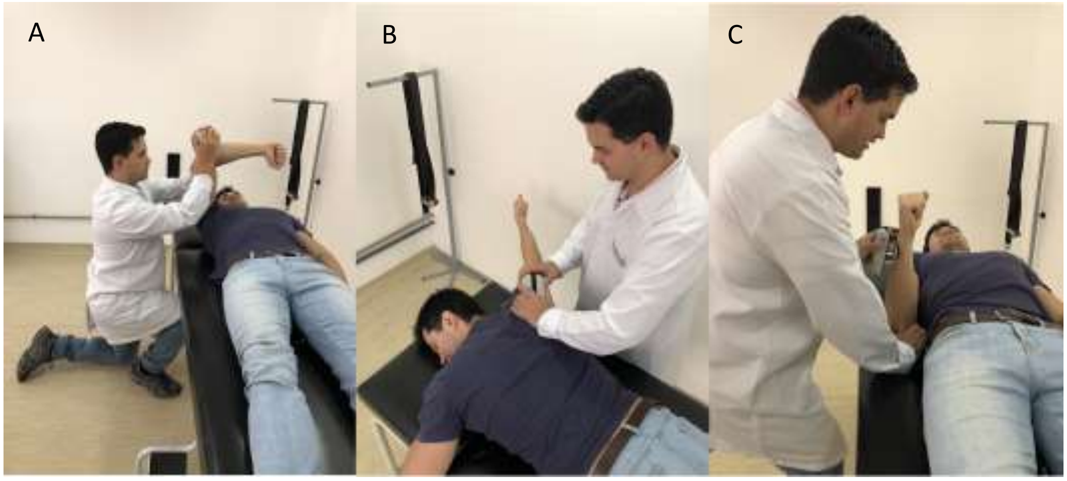

Figure 5: Assessment of muscle force production: **A** – serratus anterior test. **B** – lower trapezius test. **C** – infraspinatus test.

Pain and exposure variables

The Visual Analogue Scale (VAS) was used to evaluate the current pain intensity at rest during the evaluation. Duration of symptoms (in months) and sleeping disturbance related to shoulder pain (positive/negative) were also recorded. Current occupation involving overhead movement (yes/no) or overhead sports participation (yes/no) were recorded as exposure variables. Additionally, dominant shoulder involvement (positive/negative) was also included in this category since the dominant arm is frequently required to perform most daily living activities.

Pain catastrophizing

Pain catastrophizing was assessed with the Brazilian version of the Pain Catastrophizing Scale (PCS). The PCS contains 13 statements related to thoughts and feelings that represent pain catastrophizing and its underlying constructs such as pain magnification, helplessness, and rumination.[39] This scale ranges from 0 to

52 with 0 as the best and 52 as the worst possible score. The PCS exhibits adequate construct validity and reliability (intraclass correlation coefficient of 0.91).[39]

Demographics

Participants height and weight were collected to calculate the body mass index (BMI). BMI was determined by dividing the weight by the square of the body height. Age was registered in years and sex was collected as a binary variable (male or female).

Special tests

Special shoulder tests commonly used to diagnose subacromial impingement syndrome, internal impingement, biceps and/or labrum lesions, shoulder laxity, and performance tests related to tendon structural integrity were assessed in all individuals. The following tests were applied in random order: Neer,[40] Hawkins-Kennedy, [41] Yocum,[42] empty can,[43] cross-body adduction,[44] acromioclavicular joint tenderness (AC shear test),[45] Speed's test,[46,47] O'Brien's test,[48] biceps load II,[49,50] belly-press,[51] bear-hug,[52] external rotation lag sign,[53] sulcus,[54] anterior drawer,[55] and Jobe relocation test (**Figure 6**).[56]

Figure 6: Special tests: **A** – Neer. **B** – Hawkins-Kennedy. **C** – Yocum. **D** – Jobe. **E** – Cross-arm. **F** – Acromioclavicular passive joint mobility (shear test). **G** – Speed's. **H** and **I** – O'Brien's. **J** – Biceps load II. **K** – Relocation. **L** – Belly-press. **M** – Drawer. **N** – Bear-hug. **O** – External rotation lag sign. **P** – Sulcus sign.

Magnetic Resonance Imaging

Individuals underwent a standardized magnetic resonance imaging (MRI) examination with gradient echo in T2 and spin-echo sequences in T1, T2, and proton density to determine the presence of structural abnormalities. All scans included slices with 3.5 to 4.0 millimeter of thickness in sagittal, coronal and axial planes without contrast material. A 1.5 Tesla-MRI device (Magnetom Essenza, Siemens®) with 18 cm field of view and dedicated shoulder array coil was utilized. MRI scans were interpreted by a board-certified orthopedic surgeon with at least 12 years of shoulder specialized experience after fellowship training. The following MRI findings, which are frequently evaluated in patients with shoulder pain, were identified as present or absent in subjects enrolled in this study: tendinopathy in the supraspinatus (SST), infraspinatus (IST) or subscapularis (SSC) tendons (including bursal or articular side assessment of the SST and IST), partial or full-thickness tear of the SST, IST, and SSC (including assessment of the anterior and posterior portions of the SST and IST as well as the superior and inferior portions of the SSC), musculotendinous retraction (yes/no), fatty infiltration (yes/no), supraspinatus muscle atrophy (yes/no), labrum abnormalities (yes/no), biceps lesion (yes/no), paralabral cyst (yes/no), glenohumeral joint osteoarthritis (yes/no), signs of adhesive capsulitis (yes/no), cyst or high intensity sign in the humeral tuberosities (yes/no), acromioclavicular joint alterations (yes/no), and increased subacromial fluid (yes/no).[57–59]

Statistical Analysis

Intrarater reliability between repeated measurements for assessing ROM and muscle force production was determined using the intraclass correlation coefficient ($ICC_{3,1}$) and standard error of the measurement (SEM). ICCs ranged from 0.93 to

0.97 (SEM, 2.24º - 3.94º) for ROM, and from 0.95 to 0.97 (SEM, 0.00kg - 0.02kg) for muscle force production.

Multivariate Model

Initially, we determined eight main categories that clustered variables of interest related to demographics, pain catastrophizing, pain intensity, exposure, ROM, muscle force production, special tests, and MR imaging. Variables within each category were considered as possible predictors to be tested in a multivariate model considering the DASH score as the "outcome" variable. First, associations between each of the potential predictors within each category and the DASH score were tested by Pearson correlation or Point-biserial test (Appendix Table 1). Next, because the number of variables had to be reduced, the predictor from each category with the highest statistically significant correlation with the DASH score was retained for the multivariate model analysis. No continuous variable was dichotomized, so that all variables were considered in units as they are typically used in the clinical setting.

The retained variables were utilized as predictors in two multivariate regression models using the DASH score as the dependent variable. The first model included all retained variables from each category, except MRI variables. The second model added the most strongly correlated MRI variable to the model. Both models were compared to each other using the adjusted total explained variance (adjusted-R^2) and Akaike Information Criterion (AIC).[60–62] Internal validation of the models was performed with a bootstrap validation approach to adjust coefficients for overfitting and estimate apparent performance.[23,63,64] A thousand new samples were created with simple sampling and bias-corrected and accelerated method combined to calculate confidence intervals.[23,63,64] The model with the highest adjusted-R^2 and the smallest AIC was presumed to best explain the DASH variance. Multicollinearity was avoided by identifying high correlation between predictors, small tolerance, and variance inflation factor values.[65] If multicollinearity was identified, the variable of the pair of associated variables most associated to the DASH was retained and the other variable of the pair was eliminated from the model. Association between categorical predictors was assessed by Phi and Cramer's V statistics, and Chi-square test for independence. Four individuals with MRI missing data were removed from the multivariate analysis to conduct a complete-case analysis.[66] IBM SPSS Statistics, version 23 (IBM Corp, Armonk, NY) was used to perform all statistical analyses.

RESULTS

Eighty-one individuals completed the study. Four individuals did not complete the MRI examination due to claustrophobia. The average DASH score was 24.81 (SD, 16.53; range, 1.66 - 79.17). Demographics are presented in the **Appendix Table 1**. The average PCS score was 20.88 (1.00 - 50.00), average pain at rest was 1.18 (0.00 - 7.50), and average duration of symptoms was 35.41 (1.00 - 360.00) months. The dominant side was involved in 49 (60.5%) individuals, 20 (24.7%) had current exposure to overhead work, and twelve were currently involved in overhead sports (14.8%). Range of motion, muscle force production, positive special test frequency, and the frequency of all MRI findings are described in the **Appendix table 1**.

Based on univariate association to the DASH, the following variables were selected for the multivariate model from each category; ROM: glenohumeral external rotation; muscle force production: lower trapezius test; pain: VAS; demographics: sex; PCS; exposure: overhead sports participation; special tests: AC joint tenderness; and MRI: presence of IST tendinopathy on the bursal side. The correlation coefficients of all the potential predictors can be observed in the **Appendix table 1**. The variables selected from each category and that were included in the model had significant univariate correlations ranging from a low of -0.311 for overhead sports participation, to a high of 0.444 for the AC shear test.

The first model without MRI data explained 64.6% of the DASH score variance. The pain intensity and PCS were the strongest explanatory variables individually explaining 16.00% and 6.76% of the DASH score variance, respectively (**Table 1**). Sex was inversely related to the DASH scores explaining 3.61% of the DASH variance, indicating lower DASH scores were more frequently attributed to female individuals.

The inclusion of a single MRI variable in the final model did not substantively change the model R^2 (64.2%). The AIC was similar in the final model suggesting that the models did not differ in explaining the DASH variance (**Table 1**). After the internal validation, the same variables exhibited statistically significant contribution to the model (**Table 2**).

DISCUSSION

The main findings of this study showed that pain at rest and PCS were the best explanatory variables of the DASH score. In summary, the higher the pain intensity or pain catastrophizing, the worse was the self-reported shoulder function. Also, adding a single MRI variable to the analysis as a representation of pathoanatomical findings did not further explain patient self-reported shoulder function. DASH items related to the symptom severity are more likely to be associated with the pain at rest as they share the same domain. In fact, self-reported function may be more influenced by pain when compared with other assessment methods such as performance-based instruments.[67] We believe that the association between PCS and DASH was observed due to the DASH characteristic of evaluating more activities and body functions in comparison to other questionnaires.

It is also interesting that the AC joint tenderness test and sex statistically contributed individually to both models, while ROM, strength, and exposure variables did not. However, it should be emphasized that although sex and the AC joint tenderness statistically contributed to the model, they were not strong explanatory variables based on the semipartial correlations.

In our study, pain at rest individually explained 15% of the DASH variance. Other investigations did not identify pain intensity as an important explanatory variable of self-reported function.[18,19] Ekeberg et al.[18] tested the relationship between pain during activity and SPADI scores in patients receiving corticosteroid injections, and while pain presented an univariate association to SPADI score, it was not retained in a multivariate analysis when considered with several other variables. Patients evaluated in Ekeberg's study presented higher pain intensity (6.2 on average) than the individuals assessed in our study (1.18), which may have contributed to the inconsistency observed between our results. Chester et al.[68] evaluated the relationship between shoulder pain intensity and SPADI score and a statistically significant contribution was reported.[68] Differences regarding the relationship of pain to shoulder function in that study compared to ours may occur because individuals with neck pain, shoulder instability and shoulder stiffness as well as other comorbidities were included

Psychosocial factors such as patient's expectation of change, somatization, anxiety or depression were previously shown to relate to self-reported upper extremity function, but results are inconsistent.[11,12,68–70] Kromer et al.[12] reported no statistically significant relationship between pain catastrophizing and shoulder function but most participants on that study reported low PCS scores (median = 9) suggesting that only a few individuals were presenting a catastrophic behavior, likely resulting in the limited contribution to the model. Coronado et al. (2017)[11] observed a negative relationship between pain catastrophizing and shoulder function as measured by the Pennsylvania Shoulder Score that was moderated by their measure of optimism, a positive psychological factor. The explained variance in Coronado's study ranged from 15% to 69% with Beta values between -0.42 and -0.19 suggesting an inverse relationship between PCS and shoulder function consistent with our results. In addition, it is suggested that patients exhibiting pain catastrophizing are more likely to present maladaptive movements and avoidance as they tend to believe in a potential or actual cause of injury related to that activities.[71] Therefore, it may be beneficial to identify which patients will most benefit from interventions for decreasing catastrophizing levels.

The relationship between pathoanatomical factors on shoulder function is inconsistently reported.[14,72–74] In our study, only three MRI variables showed statistically significant univariate association with the DASH. The variables that presented association with the DASH had a low frequency of positive findings (**Appendix Table 1**). This may be the reason for the poor relationships in our analysis. MRI alone may not provide sufficient or valuable information regarding shoulder function in patients presenting with shoulder pain. It is possible a multivariate model of imaging findings would demonstrate a stronger association with self-reported function. However, we and others[14,72–74] have provided information that MRI findings are overused in the early management of patients with shoulder pain, due to a high cost relative to the benefit. It is worth emphasizing, however, that pathoanatomy can be important to clinical decision-making in patients with shoulder pain. We suggest MRI information be judiciously considered with the other components of clinical evaluation to avoid assumed relationships to pain and function and unnecessary treatment costs.

Other variables within each category showed association with the DASH but were not selected for the multivariate model (**Appendix Table 1**). Worse self-reported upper extremity function was associated to older participants, but the strength of the association was not as strong as that observed between sex and the DASH. That may be due to the inclusion of mostly middle-aged adults and high age variability in our study. Physical measures such as the ROM of shoulder flexion or abduction were similarly associated to the DASH score as the ROM of shoulder external rotation, which was selected to the model. Decreased shoulder flexion and abduction were associated with worse self-reported function. Similarly, the infraspinatus muscle test force production was nearly as associated with the DASH as the force production during the lower trapezius test. Therefore, although these variables were not selected to the model, they showed significant association with self-reported upper extremity function and are important variable to be considered in clinical evaluation and treatment.

Our hypotheses were not fully supported by the results. Surprisingly, the ROM of shoulder external rotation and the force production from the lower trapezius test have not shown an independent and significant contribution to the model before or after the internal validation. The fact that most patients in our study had just a mild or nonexistent shoulder range of motion and muscle force production deficit (~10%) may have contributed to these results (**Appendix Table 1**). In addition, less than 15% of the participants in our study were involved in overhead sports practice, meaning that physical measures and pain perception data are more representative of the non-athlete population. Pain intensity and clinical presentation may be highly variable and individuals with shoulder pain do not usually present high pain intensity at rest. For instance, in a large observational study, van der Windt et al. (1995) evaluated clinical features associated with different specific shoulder diagnosis such as adhesive capsulitis, acute bursitis, subacromial pain syndrome, and tendinitis in 335 individuals and observed that pain intensity above seven points on a 11-point scale was reported between 16% and 20%.[9] Gumina et al. (2014) found different results with an average pain intensity varying between 4.6 and 5.8 in patients with different rotator cuff tear sizes but the variation of pain intensity levels was very high with values from 0 to 9.3 and patients were 65 years old on average.[75] We believe our results are best applicable to patients with low pain intensity levels at rest. Our model would likely have greater generalizability if we had included patients with a broader clinical presentation, especially related to range of motion, muscle strength, and pain intensity because that would add variability to our model.

Additional predictors such as depression, job status, self-efficacy, and education level are important factors that were not tested in the current study. We were aware that those variables might play a role in explaining shoulder function but adding more variables would have increased the risk of overfitting the model. That is important since adding more variables increases the degrees of freedom and reduces the power of accurately detecting true relationships. Also, only pain at rest was included in the analysis as our inclusion criteria was the presence of shoulder pain. Patients reported pain in a myriad of situations like during very specific movements and activities and not always during shoulder elevation. This may jeopardize sample homogeneity, but on the other hand, best reflects the real world. We suggest collecting the pain intensity in more than only one situation such as at rest, movement, and worst pain on the week. That can help to capture a more comprehensive clinical status during the evaluation. There is no definitive consensus about how to select the best set of explanatory variables to include in the model when there are more available explanatory variables than sample size allows for consideration. Although a common approach, verifying the correlation between explanatory variables and the outcome may leave important variables out from the model. Selecting explanatory variables using a significance-based method may also leave important variables out of the model while automatic selection methods may frequently yield optimistic and overfitted models with inaccurate parameters.[23] Consequently, different results might have been observed depending on the selection method. Despite the study's limitations, our study provides important data since a substantial portion of the DASH score variance was explained by the retained explanatory variables and their relationship was confirmed using an internal validation approach.

CONCLUSIONS

Pain at rest and pain catastrophizing were the measures of the clinical evaluation most associated to the self-reported DASH score in our analysis. All physical measures assessed in our study that were not selected to the model still demonstrated association with upper extremity function. Inclusion in a multivariate model of the most highly associated MR imaging finding did not improve the model performance and most imaging variables were not significantly associated to the outcome when considered individually.

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REFERENCES

1. Feleus A, Bierma-Zeinstra SMA, Miedema HS, Bernsen RMD, Verhaar J a. N, Koes BW. Incidence of non-traumatic complaints of arm, neck and shoulder in general practice. *Man Ther*. 2008;13(5):426-433. doi:10.1016/j.math.2007.05.010

2. Luime JJ, Koes BW, Hendriksen IJM, et al. Prevalence and incidence of shoulder pain in the general population: a systematic review. *Scand J Rheumatol*. 2004;33(2):73-81.

3. Klintberg IH, Cools AMJ, Holmgren TM, et al. Consensus for physiotherapy for shoulder pain. *Int Orthop*. 2015;39(4):715-720. doi:10.1007/s00264-014-2639-9

4. Mitchell C, Adebajo A, Hay E, Carr A. Shoulder pain: diagnosis and management in primary care. *BMJ*. 2005;331(7525):1124-1128.

5. Triffitt PD. The relationship between motion of the shoulder and the stated ability to perform activities of daily living. *J Bone Joint Surg Am*. 1998;80(1):41-46.

6. Harrington S, Padua D, Battaglini C, Michener LA. Upper extremity strength and range of motion and their relationship to function in breast cancer survivors. *Physiother Theory Pract*. 2013;29(7):513-520. doi:10.3109/09593985.2012.757683

7. Kuijpers T, van der Windt DAWM, Boeke AJ, et al. Clinical prediction rules for the prognosis of shoulder pain in general practice. *Pain*. 2006;120(3):276-285. doi:10.1016/j.pain.2005.11.004

8. Kuijpers T, van der Windt DAWM, van der Heijden GJMG, Bouter LM. Systematic review of prognostic cohort studies on shoulder disorders. *Pain*. 2004;109(3):420-431. doi:10.1016/j.pain.2004.02.017

9. van der Windt DA, Koes BW, de Jong BA, Bouter LM. Shoulder disorders in general practice: incidence, patient characteristics, and management. *Ann Rheum Dis*. 1995;54(12):959-964.

10. Quartana PJ, Campbell CM, Edwards RR. Pain catastrophizing: a critical review. *Expert Rev Neurother*. 2009;9(5):745-758. doi:10.1586/ERN.09.34

11. Coronado RA, Simon CB, Lentz TA, Gay CW, Mackie LN, George SZ. Optimism Moderates the Influence of Pain Catastrophizing on Shoulder Pain Outcome: A Longitudinal Analysis. *J Orthop Sports Phys Ther*. 2017;47(1):21-30. doi:10.2519/jospt.2017.7068

12. Kromer TO, Sieben JM, de Bie RA, Bastiaenen CHG. Influence of fear-avoidance beliefs on disability in patients with subacromial shoulder pain in

primary care: a secondary analysis. *Phys Ther*. 2014;94(12):1775-1784. doi:10.2522/ptj.20130587

13. Menendez ME, Baker DK, Oladeji LO, Fryberger CT, McGwin G, Ponce BA. Psychological Distress Is Associated with Greater Perceived Disability and Pain in Patients Presenting to a Shoulder Clinic. *J Bone Joint Surg Am*. 2015;97(24):1999-2003. doi:10.2106/JBJS.O.00387

14. Russell RD, Knight JR, Mulligan E, Khazzam MS. Structural integrity after rotator cuff repair does not correlate with patient function and pain: a meta-analysis. *J Bone Joint Surg Am*. 2014;96(4):265-271. doi:10.2106/JBJS.M.00265

15. Brox JI, Brevik JI. Prognostic factors in patients with rotator tendinosis (stage II impingement syndrome) of the shoulder. *Scand J Prim Health Care*. 1996;14(2):100-105.

16. Macfarlane GJ, Hunt IM, Silman AJ. Predictors of chronic shoulder pain: a population based prospective study. *J Rheumatol*. 1998;25(8):1612-1615.

17. Bartolozzi A, Andreychik D, Ahmad S. Determinants of outcome in the treatment of rotator cuff disease. *Clin Orthop*. 1994;(308):90-97.

18. Ekeberg OM, Bautz-Holter E, Juel NG, Engebretsen K, Kvalheim S, Brox JI. Clinical, socio-demographic and radiological predictors of short-term outcome in rotator cuff disease. *BMC Musculoskelet Disord*. 2010;11:239. doi:10.1186/1471-2474-11-239

19. Uhl TL, Smith-Forbes EV, Nitz AJ. Factors influencing final outcomes in patients with shoulder pain: A retrospective review. *J Hand Ther*. 2017;30(2):200-207. doi:10.1016/j.jht.2017.04.004

20. Croft P, Pope D, Silman A. The clinical course of shoulder pain: prospective cohort study in primary care. Primary Care Rheumatology Society Shoulder Study Group. *BMJ*. 1996;313(7057):601-602.

21. Clausen MB, Witten A, Holm K, et al. Glenohumeral and scapulothoracic strength impairments exists in patients with subacromial impingement, but these are not reflected in the shoulder pain and disability index. *BMC Musculoskelet Disord*. 2017;18(1):302. doi:10.1186/s12891-017-1667-1

22. Kennedy CA, Manno M, Hogg-Johnson S, et al. Prognosis in soft tissue disorders of the shoulder: predicting both change in disability and level of disability after treatment. *Phys Ther*. 2006;86(7):1013-1032; discussion 1033-1037.

23. Moons KG, Altman DG, Reitsma JB, et al. Transparent Reporting of a multivariable prediction model for Individual Prognosis or Diagnosis (TRIPOD):

explanation and elaboration. *Ann Intern Med*. 2015;162(1):W1-73. doi:10.7326/M14-0698

24. Babyak MA. What you see may not be what you get: a brief, nontechnical introduction to overfitting in regression-type models. *Psychosom Med*. 2004;66(3):411-421.

25. Ginn KA, Cohen ML. Conservative treatment for shoulder pain: prognostic indicators of outcome. *Arch Phys Med Rehabil*. 2004;85(8):1231-1235. doi:10.1016/j.apmr.2003.09.013

26. Zheng X, Simpson JA, van der Windt DA, Elliott AM. Data from a study of effectiveness suggested potential prognostic factors related to the patterns of shoulder pain. *J Clin Epidemiol*. 2005;58(8):823-830. doi:10.1016/j.jclinepi.2005.01.011

27. Solomon DH, Bates DW, Schaffer JL, Horsky J, Burdick E, Katz JN. Referrals for musculoskeletal disorders: patterns, predictors, and outcomes. *J Rheumatol*. 2001;28(9):2090-2095.

28. Kelley MJ, Shaffer MA, Kuhn JE, et al. Shoulder pain and mobility deficits: adhesive capsulitis. *J Orthop Sports Phys Ther*. 2013;43(5):A1-31. doi:10.2519/jospt.2013.0302

29. Rubinstein SM, Pool JJM, van Tulder MW, Riphagen II, de Vet HCW. A systematic review of the diagnostic accuracy of provocative tests of the neck for diagnosing cervical radiculopathy. *Eur Spine J Off Publ Eur Spine Soc Eur Spinal Deform Soc Eur Sect Cerv Spine Res Soc*. 2007;16(3):307-319. doi:10.1007/s00586-006-0225-6

30. Orfale AG, Araújo PM, Ferraz MB, Natour J. Translation into Brazilian Portuguese, cultural adaptation and evaluation of the reliability of the Disabilities of the Arm, Shoulder and Hand Questionnaire. *Braz J Med Biol Res*. 2005;38(2):293-302. doi:/S0100-879X2005000200018

31. Haik MN, Alburquerque-Sendín F, Moreira RFC, Pires ED, Camargo PR. Effectiveness of physical therapy treatment of clearly defined subacromial pain: a systematic review of randomised controlled trials. *Br J Sports Med*. 2016;50(18):1124-1134. doi:10.1136/bjsports-2015-095771

32. Camargo PR, Haik MN, Filho RB, Mattiello-Rosa SM, Salvini TF. Pain in workers with shoulder impingement syndrome: an assessment using the DASH and McGill pain questionnaires. *Braz J Phys Ther*. 2007;11(2):161-167. doi:10.1590/S1413-35552007000200012

33. Roy J-S, Esculier J-F. Psychometric evidence for clinical outcome measures assessing shoulder disorders. *Phys Ther Rev*. 2011;16(5):331-346. doi:10.1179/1743288X11Y.0000000043

34. Roy J-S, MacDermid JC, Woodhouse LJ. Measuring shoulder function: a systematic review of four questionnaires. *Arthritis Rheum*. 2009;61(5):623-632. doi:10.1002/art.24396

35. Roe Y, Soberg HL, Bautz-Holter E, Ostensjo S. A systematic review of measures of shoulder pain and functioning using the International classification of functioning, disability and health (ICF). *BMC Musculoskelet Disord*. 2013;14:73. doi:10.1186/1471-2474-14-73

36. Michener LA, Boardman ND, Pidcoe PE, Frith AM. Scapular muscle tests in subjects with shoulder pain and functional loss: reliability and construct validity. *Phys Ther*. 2005;85(11):1128-1138.

37. Cools AM, De Wilde L, Van Tongel A, Ceyssens C, Ryckewaert R, Cambier DC. Measuring shoulder external and internal rotation strength and range of motion: comprehensive intra-rater and inter-rater reliability study of several testing protocols. *J Shoulder Elbow Surg*. 2014;23(10):1454-1461. doi:10.1016/j.jse.2014.01.006

38. Hurd WJ, Morrey BF, Kaufman KR. The effects of anthropometric scaling parameters on normalized muscle strength in uninjured baseball pitchers. *J Sport Rehabil*. 2011;20(3):311-320.

39. Sehn F, Chachamovich E, Vidor LP, et al. Cross-cultural adaptation and validation of the Brazilian Portuguese version of the pain catastrophizing scale. *Pain Med Malden Mass*. 2012;13(11):1425-1435. doi:10.1111/j.1526-4637.2012.01492.x

40. Neer CS. Impingement lesions. *Clin Orthop*. 1983;(173):70-77.

41. Hawkins RJ, Kennedy JC. Impingement syndrome in athletes. *Am J Sports Med*. 1980;8(3):151-158. doi:10.1177/036354658000800302

42. Leroux JL, Thomas E, Bonnel F, Blotman F. Diagnostic value of clinical tests for shoulder impingement syndrome. *Rev Rhum Engl Ed*. 1995;62(6):423-428.

43. Jobe FW, Jobe CM. Painful athletic injuries of the shoulder. *Clin Orthop*. 1983;(173):117-124.

44. Caliş M, Akgün K, Birtane M, Karacan I, Caliş H, Tüzün F. Diagnostic values of clinical diagnostic tests in subacromial impingement syndrome. *Ann Rheum Dis*. 2000;59(1):44-47.

45. Davies GJ, Gould JA, Larson RL. Functional Examination of the Shoulder Girdle. *Phys Sportsmed*. 1981;9(6):82-104. doi:10.1080/00913847.1981.11711099

46. Chen H-S, Lin S-H, Hsu Y-H, Chen S-C, Kang J-H. A comparison of physical examinations with musculoskeletal ultrasound in the diagnosis of biceps long head tendinitis. *Ultrasound Med Biol*. 2011;37(9):1392-1398. doi:10.1016/j.ultrasmedbio.2011.05.842

47. Bennett WF. Specificity of the Speed's test: arthroscopic technique for evaluating the biceps tendon at the level of the bicipital groove. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc*. 1998;14(8):789-796.

48. O'Brien SJ, Pagnani MJ, Fealy S, McGlynn SR, Wilson JB. The active compression test: a new and effective test for diagnosing labral tears and acromioclavicular joint abnormality. *Am J Sports Med*. 1998;26(5):610-613. doi:10.1177/03635465980260050201

49. Kim SH, Ha KI, Ahn JH, Kim SH, Choi HJ. Biceps load test II: A clinical test for SLAP lesions of the shoulder. *Arthroscopy*. 2001;17(2):160-164. doi:10.1053/jars.2001.20665

50. Kim S-H, Ha K-I, Han K-Y. Biceps Load Test: A Clinical Test for Superior Labrum Anterior and Posterior Lesions in Shoulders With Recurrent Anterior Dislocations. *Am J Sports Med*. 1999;27(3):300-303. doi:10.1177/03635465990270030501

51. Gerber C, Hersche O, Farron A. Isolated rupture of the subscapularis tendon. *J Bone Joint Surg Am*. 1996;78(7):1015-1023.

52. Barth JRH, Burkhart SS, De Beer JF. The bear-hug test: a new and sensitive test for diagnosing a subscapularis tear. *Arthroscopy*. 2006;22(10):1076-1084. doi:10.1016/j.arthro.2006.05.005

53. Hertel R, Ballmer FT, Lombert SM, Gerber C. Lag signs in the diagnosis of rotator cuff rupture. *J Shoulder Elbow Surg*. 1996;5(4):307-313.

54. Bigliani LU, Codd TP, Connor PM, Levine WN, Littlefield MA, Hershon SJ. Shoulder Motion and Laxity in the Professional Baseball Player. *Am J Sports Med*. 1997;25(5):609-613. doi:10.1177/036354659702500504

55. Gerber C, Ganz R. Clinical assessment of instability of the shoulder. With special reference to anterior and posterior drawer tests. *J Bone Joint Surg Br*. 1984;66-B(4):551-556.

56. Rockwood CA, Matsen FA. *The Shoulder*. 1st ed. Saunders; 1990.

57. Vahlensieck M. MRI of the shoulder. *Eur Radiol*. 2000;10(2):242-249. doi:10.1007/s003300050040

58. Mulyadi E, Harish S, O'Neill J, Rebello R. MRI of impingement syndromes of the shoulder. *Clin Radiol*. 2009;64(3):307-318. doi:10.1016/j.crad.2008.08.013

59. Farshad-Amacker NA, Jain Palrecha S, Farshad M. The primer for sports medicine professionals on imaging: the shoulder. *Sports Health*. 2013;5(1):50-77. doi:10.1177/1941738112468265

60. Snipes M, Taylor DC. Model selection and Akaike Information Criteria: An example from wine ratings and prices. *Wine Econ Policy*. 2014;3(1):3-9. doi:10.1016/j.wep.2014.03.001

61. Symonds MRE, Moussalli A. A brief guide to model selection, multimodel inference and model averaging in behavioural ecology using Akaike's information criterion. *Behav Ecol Sociobiol*. 2011;65(1):13-21. doi:10.1007/s00265-010-1037-6

62. Akaike H. A new look at the statistical model identification. *IEEE Trans Autom Control*. 1974;19(6):716-723. doi:10.1109/TAC.1974.1100705

63. Efron B, Tibshirani RJ. *An Introduction to the Bootstrap*. 1st ed. New York: Chapman and Hall/CRC; 1994.

64. IBM Knowledge Center - Jackknife Sampling (bootstrapping algorithms). https://www.ibm.com/support/knowledgecenter/en/SSLVMB_22.0.0/com.ibm.spss.statistics.algorithms/alg_bootstrap_sampling_jackknife.htm. Accessed March 2, 2018.

65. Field A. *Discovering Statistics Using IBM SPSS Statistics*. 4th ed. Sage Publications; 2013.

66. Janssen KJM, Vergouwe Y, Donders ART, et al. Dealing with missing predictor values when applying clinical prediction models. *Clin Chem*. 2009;55(5):994-1001. doi:10.1373/clinchem.2008.115345

67. Terwee CB, van der Slikke RMA, van Lummel RC, Benink RJ, Meijers WGH, de Vet HCW. Self-reported physical functioning was more influenced by pain than performance-based physical functioning in knee-osteoarthritis patients. *J Clin Epidemiol*. 2006;59(7):724-731. doi:10.1016/j.jclinepi.2005.11.019

68. Chester R, Jerosch-Herold C, Lewis J, Shepstone L. Psychological factors are associated with the outcome of physiotherapy for people with shoulder pain: a multicentre longitudinal cohort study. *Br J Sports Med*. 2018;52(4):269-275. doi:10.1136/bjsports-2016-096084

69. Karel YHJM, Verhagen AP, Thoomes-de Graaf M, et al. Development of a Prognostic Model for Patients With Shoulder Complaints in Physical Therapist Practice. *Phys Ther*. 2017;97(1):72-80. doi:10.2522/ptj.20150649

70. Lentz TA, Barabas JA, Day T, Bishop MD, George SZ. The relationship of pain intensity, physical impairment, and pain-related fear to function in patients with shoulder pathology. *J Orthop Sports Phys Ther*. 2009;39(4):270-277. doi:10.2519/jospt.2009.2879

71. Feleus A, van Dalen T, Bierma-Zeinstra SMA, et al. Kinesiophobia in patients with non-traumatic arm, neck and shoulder complaints: a prospective cohort study in general practice. *BMC Musculoskelet Disord*. 2007;8:117. doi:10.1186/1471-2474-8-117

72. Chalmers PN, Ross H, Granger E, Presson AP, Zhang C, Tashjian RZ. The Effect of Rotator Cuff Repair on Natural History: A Systematic Review of Intermediate to Long-Term Outcomes. *JBJS Open Access*. 2018;3(1):e0043. doi:10.2106/JBJS.OA.17.00043

73. Schibany N, Zehetgruber H, Kainberger F, et al. Rotator cuff tears in asymptomatic individuals: a clinical and ultrasonographic screening study. *Eur J Radiol*. 2004;51(3):263-268. doi:10.1016/S0720-048X(03)00159-1

74. Moosmayer S, Smith H-J, Tariq R, Larmo A. Prevalence and characteristics of asymptomatic tears of the rotator cuff: an ultrasonographic and clinical study. *J Bone Joint Surg Br*. 2009;91(2):196-200. doi:10.1302/0301-620X.91B2.21069

75. Gumina S, Candela V, Passaretti D, et al. Intensity and distribution of shoulder pain in patients with different sized postero-superior rotator cuff tears. *J Shoulder Elbow Surg*. 2014;23(6):807-813. doi:10.1016/j.jse.2013.09.011.

Table 1. Multiple regression results

Variables in model	Adjusted R^2	AIC	Unstandardized B (Std. error)	Standardized B	95% C.I. for B		Semipartial correlation	$Part^2$	p-value
					Lower	Upper			
Model 1	64.6%	359.71							
Sex			-7.18 (2.54)	-.21	-12.27	-2.10	-.19	3.61%	.006*
ROM of shoulder external rotation			-.09 (.06)	-.13	-.23	.03	-.09	0.81%	.150
VAS			3.47 (.58)	.44	2.31	4.64	.40	16%	≤.001*
PCS			.37 (.09)	.28	.18	.57	.26	6.76%	≤.001*
Overhead sports exposure			-5.67 (3.57)	-.12	-12.79	1.44	-.10	1%	.116
Lower trapezius test			-34.22 (23.91)	-.13	-81.94	13.49	-.09	0.81%	.157
AC joint tenderness			6.67 (2.47)	.19	1.73	11.60	.18	3.24%	.009*
Model 2	64.2%	361.48							
Sex			-7.00 (2.59)	-.21	-12.18	-1.83	-.18	3.24%	.009*
ROM of external rotation			-.09 (.06)	-.12	-.23	.04	-.09	0.81%	.162
VAS			3.42 (.59)	.43	2.23	4.61	.39	15.21%	≤.001*
PCS			.37 (.09)	.28	.17	.57	.26	6.76%	≤.001*
Overhead sports			-5.66 (3.59)	-.12	-12.82	1.50	-.10	1%	.120
Lower trapezius test			-33.03 (24.20)	-.12	-81.32	15.26	-.09	0.81%	.177
AC joint tenderness			6.61 (2.49)	.19	1.64	11.58	.18	3.24%	.010*
Tendinopathy IST bursal side			-2.50 (5.55)	-.03	-13.58	8.57	-.03	0.09%	.653

AIC= Akaike Information Criterion; C.I.= Confidence Interval; Std.= Standard; ROM= Range of Motion; VAS= Visual Analog Scale; AC= Acromioclavicular; PCS= Pain Catastrophizing Scale; LT= Lower Trapezius Muscle; IST= Infraspinatus muscle; $Part^2$= squared semipartial correlation; *= statistical significance.

Table 2. Internal Validation Bootstrap for Coefficients

Variables in model	Adjusted R^2	Unstandardized B (Std. error)	Bias	95% C.I. for B		p-value
				Lower	Upper	
Model 1	64.6%					
Sex		-7.18 (2.58)	.13	-12.32	-1.89	.008*
ROM of external rotation		-.09 (.08)	-.00	-.25	.02	.240
VAS		3.47 (.62)	-.01	2.26	4.75	≤.001*
PCS		.37 (.10)	-.01	.17	.54	.002*
Overhead sports exposure		-5.67 (2.92)	.18	-11.18	1.54	.064
Lower trapezius test		-34.22 (28.77)	-.37	-88.38	22.21	.251
AC joint tenderness		6.67 (2.63)	-.12	1.92	11.23	.019*
Model 2	64.2%					
Sex		-7.00 (2.62)	.15	-12.10	-1.63	.011*
ROM of external rotation		-.09 (.08)	-.01	-.27	.05	.269
VAS		3.42 (.65)	-.04	2.13	4.77	≤.001*
PCS		.37 (.11)	-.01	.13	.57	.002*
Overhead sports exposure		-5.66 (2.94)	.22	-10.88	.72	.065
Lower trapezius test		-33.03 (29.42)	.75	-91.54	26.76	.283
AC joint tenderness		6.61 (2.68)	.03	1.37	12.06	.023*
Tendinopathy IST bursal side		-2.50 (5.62)	.03	-14.46	8.13	.617

C.I.= Confidence Interval; Std.= Standard; ROM= Range of Motion; VAS= Visual Analog Scale; AC= Acromioclavicular; PCS= Pain Catastrophizing Scale; LT= Lower Trapezius Muscle; IST= Infraspinatus muscle; *= statistical significance.

Appendix table 1. Correlation between DASH score and potential predictor variables

Potential predictors	**Mean or frequency**	**SD**	**Correlation coefficient**	**p**
Demographics				
Age (years)	41.76	16.49	.27	.01*
Sex	46 men 35 women		-.41	.00*
BMI (kg/m^2)	25.30	3.01	-.13	.25
Range of motion (degrees)				
Shoulder flexion	166.72	13.47	-.38	.00*
Shoulder abduction	155.22	25.25	-.38	.00*
Shoulder internal rotation	70.14	14.36	.16	.16
Shoulder external rotation	90.03	21.56	-.38	.00*
Pain				
Pain at rest (VAS)	1.18	2.09	.42	.00*
Duration of the symptoms (months)	35.41	61.43	-.21	.06
Sleep disturbance	25 yes 56 no		.26	.01*
Pain Catastrophizing				
PCS	20.88	12.14	.39	.00*
Exposure				
Dominant shoulder involvement	49 yes 32 no		.05	.64
Overhead work	20 yes 61 no		.14	.19
Overhead sports	12 yes 69 no		-.31	.00*
Muscle force production				
Serratus anterior test	.22	.07	-14	.21
Lower trapezius test	.13	.06	-.40	.00*
Infraspinatus test	.11	.03	-.31	.00*
Special tests				
Neer	48 positives 33 negatives		.25	.02*
Hawkins-Kennedy	48 positives 33 negatives		-.00	.98

Yocum	35 positives 46 negatives	.18	.10
Jobe	49 positives 32 negatives	.20	.07
Cross-body adduction	54 positives 27 negatives	.03	.77
Acromioclavicular joint tenderness	30 positives 51 negatives	.44	.00*
Speed's test	34 positives 45 negatives	.17	.12
O'Brien's test	36 positives 45 negatives	-.14	.21
Biceps load test II	18 positives 61 negatives 2 not performed	.03	.81
Belly-press test	5 positives 76 negatives	.03	.79
Bear-hug test	10 positives 71 negatives	.23	.04*
External rotation lag sign	81 negatives	Correlation not computed	
Sulcus sign	16 positives 65 negatives	-.33	.00*
Anterior drawer	20 positives 61 negatives	-.21	.06
Jobe relocation	23 positives 57 negatives 1 not performed	-.09	.43
MRI			
Is tendinopathy observed in the RC?	61 yes 16 no	.10	.41
Tendinopathy SST	56 yes 21 no	.01	.40
Tendinopathy IST	10 yes 67 no	.20	.08
Tendinopathy SSC	12 yes 65 no	.03	.76
Tendinopathy TM	77 no	Correlation not computed	
Tendinopathy SST bursal side	33 yes 43 no	-.01	.90

Tendinopathy SST articular side	30 yes 46 no 1 poor image quality	.12	.30
Tendinopathy SST posterior portion	33 yes 43 no 1 poor image quality	.18	.11
Tendinopathy SST anterior portion	30 yes 46 no 1 poor image quality	.08	.47
Tendinopathy IST bursal side	4 yes 73 no	.34	.00*
Tendinopathy IST articular side	4 yes 73 no	.34	.00*
Tendinopathy IST posterior portion	5 yes 72 no	.18	.11
Tendinopathy IST anterior portion	5 yes 72 no	.31	.00*
Tendinopathy SSC superior portion	7 yes 70 no	.02	.89
Tendinopathy SSC inferior portion	7 yes 70 no	-.01	.95
Tendinopathy SST intratendon	37 yes 39 no 1 poor image quality	.16	.16
Tendinopathy IST intratendon	7 yes 70 no	.20	.08
Tendinopathy SSC intratendon	7 yes 70 no	.06	.58
Is a partial-thickness tear observed in the RC?	24 yes 52 no 1 poor image quality	.02	.89
RCT SST	15 yes 62 no	-.00	.97
RCT IST	6 yes 71 no	-.02	.89
RCT SSC	7 yes 70 no	.19	.09
RCT TM	77 no	Correlation not computed	
RCT SST bursal side	3 yes 74 no	-.02	.87

RCT SST articular side	9 yes 68 no	.08	.50
RCT SST posterior portion	10 yes 67 no	.03	.81
RCT SST anterior portion	5 yes 72 no	-.01	.93
RCT IST bursal side	2 yes 75 no	-.13	.25
RCT IST articular side	3 yes 74 no	.08	.47
RCT IST posterior portion	3 yes 74 no	-.10	.37
RCT IST anterior portion	2 yes 75 no	-.03	.78
RCT SSC superior portion	6 yes 71 no	.13	.27
RCT SSC inferior portion	77 no	Correlation not computed	
RCT SST intratendon	3 yes 74 no	-.12	.30
RCT IST intratendon	1 yes 76 no	-.05	.66
RCT SSC intratendon	2 yes 75 no	-.20	.34
Is a full-thickness tear observed in the RC?	18 yes 58 no 1 poor image quality	.08	.47
full-thickness tear SST	14 yes 63 no	.04	.74
full-thickness tear IST	8 yes 69 no	-.09	.41
full-thickness tear SSC	8 yes 69 no	-.05	.68
full-thickness tear SST whole tendon	8 yes 69 no	.03	.80
full-thickness tear SST posterior portion	3 yes 74 no	-.08	.49
full-thickness tear SST anterior portion	3 yes 74 no	.11	.34
full-thickness tear IST whole tendon	2 yes 75 no	-.06	.60
full-thickness tear IST posterior portion	1 yes 76 no	.10	.41
full-thickness tear IST anterior portion	6 yes 71 no	-.17	.14

full-thickness tear SSC whole tendon	2 yes 75 no	-.06	.60
full-thickness tear SSC superior portion	6 yes 71 no	-.02	.87
full-thickness tear SSC inferior portion	77 no	Correlation not computed	
Is retraction of the SST muscle and tendon observed?	10 yes 67 no	-.02	.89
Is a labrum lesion observed?	52 yes 24 no 1 poor image quality	.10	.37
Is a biceps lesion observed?	52 yes 24 no 1 poor image quality	.05	.68
Is a paralabral cyst observed?	3 yes 73 no 1 poor image quality	-.02	.88
Is a glenohumeral osteoarthritis present?	11 yes 65 no 1 poor image quality	.02	.88
Are there signs of adhesive capsulitis on the MRI scan?	76 no 1 poor image quality	Correlation not computed	
Is an increase of the subacromial bursa fluid observed?	52 yes 25 no	.12	.28
Are there acromioclavicular alterations observed on MRI?	66 yes 11 no	.17	.13
Is cyst or high-intensity sign in the humeral tuberosities observed?	20 yes 57 no	.13	.28
Is atrophy observed in the SST muscle?	4 yes 73 no	-.07	.52
Is fatty infiltration observed in the rotator cuff muscles?	8 yes 69 no	.01	.96

BMI= Body Mass Index; VAS= Visual Analogue Scale; PCS= Pain Catastrophizing Scale; SST= supraspinatus; IST= infraspinatus; SSC= subscapularis; TM= teres minor; SA= serratus anterior; LT= lower trapezius; RC= rotator cuff; RCT= rotator cuff tear; *= statistically significance.

REFERÊNCIAS BIBLIOGRÁFICAS

BEY, M. J. et al. In vivo measurement of subacromial space width during shoulder elevation: technique and preliminary results in patients following unilateral rotator cuff repair. **Clinical Biomechanics (Bristol, Avon)**, v. 22, n. 7, p. 767–773, ago. 2007.

BRADLEY, M. P.; TUNG, G.; GREEN, A. Overutilization of shoulder magnetic resonance imaging as a diagnostic screening tool in patients with chronic shoulder pain. **Journal of Shoulder and Elbow Surgery**, v. 14, n. 3, p. 233–237, maio 2005.

BRAMAN, J. P. et al. Shoulder impingement revisited: evolution of diagnostic understanding in orthopedic surgery and physical therapy. **Medical & Biological Engineering & Computing**, v. 52, n. 3, p. 211–219, mar. 2014.

CHALMERS, P. N. et al. The Effect of Rotator Cuff Repair on Natural History: A Systematic Review of Intermediate to Long-Term Outcomes. **JBJS Open Access**, v. 3, n. 1, p. 1–11, 29 mar. 2018.

CHIMENTI, R. L.; FREY-LAW, L. A.; SLUKA, K. A. A Mechanism-Based Approach to Physical Therapist Management of Pain. **Physical Therapy**, v. 98, n. 5, p. 302–314, 1 maio 2018.

COOLS, A. M.; MICHENER, L. A. Shoulder pain: can one label satisfy everyone and everything? **British Journal of Sports Medicine**, v. 51, n. 5, p. 416–417, mar. 2017.

CORONADO, R. A. et al. Optimism Moderates the Influence of Pain Catastrophizing on Shoulder Pain Outcome: A Longitudinal Analysis. **The Journal of Orthopaedic and Sports Physical Therapy**, v. 47, n. 1, p. 21–30, jan. 2017.

DE WITTE, P. B. et al. Communication breakdown: clinicians disagree on subacromial impingement. **Medical & Biological Engineering & Computing**, v. 52, n. 3, p. 221–231, mar. 2014.

DE WITTE, P. B. et al. Heterogeneous MR arthrography findings in patients with subacromial impingement syndrome – Diagnostic subgroups? **Journal of Electromyography and Kinesiology**, International Shoulder Group 2014. v. 29, p. 64–73, ago. 2016.

DINTER, D. J. et al. [Shoulder injuries in overhead athletes: utility of MR arthrography]. **Sportverletzung Sportschaden: Organ Der Gesellschaft Fur Orthopadisch-Traumatologische Sportmedizin**, v. 22, n. 3, p. 146–152, set. 2008.

GEORGE, S. Z. et al. Biopsychosocial influence on exercise-induced injury: genetic and psychological combinations are predictive of shoulder pain phenotypes. **The Journal of Pain: Official Journal of the American Pain Society**, v. 15, n. 1, p. 68–80, jan. 2014.

GEORGE, S. Z. et al. Biopsychosocial influence on shoulder pain: risk subgroups translated across preclinical and clinical prospective cohorts. **Pain**, v. 156, n. 1, p. 148–156, jan. 2015.

GIPHART, J. E.; VAN DER MEIJDEN, O. A.; MILLETT, P. J. The effects of arm elevation on the 3-dimensional acromiohumeral distance: a biplane fluoroscopy study with normative data. **Journal of Shoulder and Elbow Surgery**, v. 21, n. 11, p. 1593–1600, nov. 2012.

HANCHARD, N. C. et al. Physical tests for shoulder impingements and local lesions of bursa, tendon or labrum that may accompany impingement. **The Cochrane Library**, 2013.

HILL, C. L. et al. Prevalence and correlates of shoulder pain and stiffness in a population-based study: the North West Adelaide Health Study. **International Journal of Rheumatic Diseases**, v. 13, n. 3, p. 215–222, ago. 2010.

JIA, X. et al. Examination of the Shoulder: The Past, the Present, and the Future: **The Journal of Bone and Joint Surgery-American Volume**, v. 91, n. Suppl 6, p. 10–18, nov. 2009.

KELLEY, M. J. et al. Shoulder pain and mobility deficits: adhesive capsulitis. **The Journal of Orthopaedic and Sports Physical Therapy**, v. 43, n. 5, p. A1-31, maio 2013.

KIBLER, W. B. et al. Clinical implications of scapular dyskinesis in shoulder injury: the 2013 consensus statement from the “Scapular Summit”. **British Journal of Sports Medicine**, v. 47, n. 14, p. 877–885, set. 2013.

KOLK, A. et al. Three-dimensional shoulder kinematics normalize after rotator cuff repair. **Journal of Shoulder and Elbow Surgery**, v. 25, n. 6, p. 881–889, jun. 2016.

KROMER, T. O. et al. Influence of fear-avoidance beliefs on disability in patients with subacromial shoulder pain in primary care: a secondary analysis. **Physical Therapy**, v. 94, n. 12, p. 1775–1784, dez. 2014.

KUIJPERS, T. et al. Clinical prediction rules for the prognosis of shoulder pain in general practice. **Pain**, v. 120, n. 3, p. 276–285, fev. 2006.

LAWRENCE, R. L. et al. Effect of glenohumeral elevation on subacromial supraspinatus compression risk during simulated reaching. **Journal of Orthopaedic Research: Official Publication of the Orthopaedic Research Society**, 10 jan. 2017.

LEFÈVRE-COLAU, M. M. et al. Kinematic patterns in normal and degenerative shoulders. Part II: Review of 3-D scapular kinematic patterns in patients with shoulder pain, and clinical implications. **Annals of Physical and Rehabilitation Medicine**, v. 61, n. 1, p. 46–53, jan. 2018.

LEWIS, J. Subacromial impingement syndrome: a musculoskeletal condition or a clinical illusion? **Physical Therapy Reviews**, 2011.

LEWIS, J. et al. Rotator Cuff Tendinopathy: Navigating the Diagnosis-Management Conundrum. **The Journal of Orthopaedic and Sports Physical Therapy**, v. 45, n. 11, p. 923–937, nov. 2015.

LEWIS, J. “Rotator Cuff Related Shoulder Pain: Assessment, Management and Uncertainties.” **Manual Therapy**, v. 23, p. 57–68, jun. 2016.

LUDEWIG, P. M. et al. Changing our diagnostic paradigm: movement system diagnostic classification. **International Journal of Sports Physical Therapy**, v. 12, n. 6, p. 884–893, nov. 2017.

LUDEWIG, P. M.; LAWRENCE, R. L.; BRAMAN, J. P. What’s in a name? Using movement system diagnoses versus pathoanatomic diagnoses. **The Journal of Orthopaedic and Sports Physical Therapy**, v. 43, n. 5, p. 280–283, maio 2013.

LUDEWIG, P. M.; REYNOLDS, J. F. The association of scapular kinematics and glenohumeral joint pathologies. **The Journal of Orthopaedic and Sports Physical Therapy**, v. 39, n. 2, p. 90–104, fev. 2009.

MCCLURE, P. W.; MICHENER, L. A. Staged Approach for Rehabilitation Classification: Shoulder Disorders (STAR-Shoulder). **Physical Therapy**, v. 95, n. 5, p. 791–800, maio 2015.

MCFARLAND, E. G. et al. Impingement is not impingement: the case for calling it “Rotator Cuff Disease”. **Muscles, Ligaments and Tendons Journal**, v. 3, n. 3, p. 196–200, ago. 2013.

MELL, A. G. et al. Effect of rotator cuff pathology on shoulder rhythm. **Journal of Shoulder and Elbow Surgery**, v. 14, n. 1 Suppl S, p. 58S-64S, fev. 2005.

MICHENER, L. A.; MCCLURE, P. W.; KARDUNA, A. R. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. **Clinical Biomechanics (Bristol, Avon)**, v. 18, n. 5, p. 369–379, jun. 2003.

MINAGAWA, H. et al. Prevalence of symptomatic and asymptomatic rotator cuff tears in the general population: From mass-screening in one village. **Journal of Orthopaedics**, v. 10, n. 1, p. 8–12, 26 fev. 2013.

MIURA, Y. et al. Three-dimensional Scapular Kinematics During Arm Elevation in Massive Rotator Cuff Tear Patients. **Progress in Rehabilitation Medicine**, v. 2, n. 0, p. 1–8, 2017.

NEER, C. S. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. **The Journal of Bone and Joint Surgery. American Volume**, v. 54, n. 1, p. 41–50, jan. 1972.

PANDYA, N. K. et al. Physical examination and magnetic resonance imaging in the diagnosis of superior labrum anterior-posterior lesions of the shoulder: a sensitivity analysis. **Arthroscopy: The Journal of Arthroscopic & Related Surgery: Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association**, v. 24, n. 3, p. 311–317, mar. 2008.

PAPADONIKOLAKIS, A. et al. Published evidence relevant to the diagnosis of impingement syndrome of the shoulder. **The Journal of Bone and Joint Surgery. American Volume**, v. 93, n. 19, p. 1827–1832, out. 2011.

PARK, H. B. et al. Diagnostic accuracy of clinical tests for the different degrees of subacromial impingement syndrome. **The Journal of Bone and Joint Surgery. American Volume**, v. 87, n. 7, p. 1446–1455, jul. 2005.

PHADKE, V.; CAMARGO, P.; LUDEWIG, P. Scapular and rotator cuff muscle activity during arm elevation: A review of normal function and alterations with shoulder impingement. **Revista Brasileira De Fisioterapia (Sao Carlos (Sao Paulo, Brazil))**, v. 13, n. 1, p. 1–9, fev. 2009.

PICAVET, H. S. J.; SCHOUTEN, J. S. A. G. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC(3)-study. **Pain**, v. 102, n. 1–2, p. 167–178, mar. 2003.

ROY, J.-S. et al. Diagnostic accuracy of ultrasonography, MRI and MR arthrography in the characterisation of rotator cuff disorders: a systematic review and meta-analysis. **British Journal of Sports Medicine**, v. 49, n. 20, p. 1316–1328, out. 2015.

SAHRMANN, S.; AZEVEDO, D. C.; DILLEN, L. V. Diagnosis and treatment of movement system impairment syndromes. **Brazilian Journal of Physical Therapy**, v. 21, n. 6, p. 391–399, 2017.

SCHREINEMACHERS, S. A. et al. Detection of partial-thickness supraspinatus tendon tears: is a single direct MR arthrography series in ABER position as accurate as conventional MR arthrography? **Skeletal Radiology**, v. 38, n. 10, p. 967–975, out. 2009.

SCIBEK, J. S.; CARPENTER, J. E.; HUGHES, R. E. Rotator Cuff Tear Pain and Tear Size and Scapulohumeral Rhythm. **Journal of Athletic Training**, v. 44, n. 2, p. 148–159, 2009.

TEKAVEC, E. et al. Population-based consultation patterns in patients with shoulder pain diagnoses. **BMC musculoskeletal disorders**, v. 13, p. 238, 29 nov. 2012.

TIMMONS, M. K. et al. Scapular kinematics and subacromial-impingement syndrome: a meta-analysis. **Journal of Sport Rehabilitation**, v. 21, n. 4, p. 354–370, nov. 2012.

VAN GRINSVEN, S. et al. Are radiologists superior to orthopaedic surgeons in diagnosing instability-related shoulder lesions on magnetic resonance arthrography? A multicenter reproducibility and accuracy study. **Journal of Shoulder and Elbow Surgery**, v. 24, n. 9, p. 1405–1412, set. 2015.

WALCH, G. et al. Impingement of the deep surface of the supraspinatus tendon on the posterosuperior glenoid rim: An arthroscopic study. **Journal of Shoulder and Elbow Surgery**, v. 1, n. 5, p. 238–245, set. 1992.