The Effectiveness of an Upper Extremity Neuromuscular Training Program on the Shoulder Function of Military Members with a Rotator Cuff Tendinopathy: A Pilot Randomized Controlled Trial

Mémoire

Amanda Ager

Maîtrise en sciences cliniques et biomédicales
Maître ès sciences (M. Sc.)

Québec, Canada

The Effectiveness of an Upper Extremity Neuromuscular Training Program on the Shoulder Function of Military Members with a Rotator Cuff Tendinopathy: A Pilot Randomized Controlled Trial

Mémoire

Amanda Ager

Sous la direction de:

Luc J. Hébert, directeur de recherche

Jean-Sébastien Roy, codirecteur de recherche

RÉSUMÉ

INTRODUCTION: La tendinopathie de la coiffe des rotateurs (TCR) entraine au quotidien des douleurs et faiblesses musculaires et une diminution du contrôle moteur à l'épaule. OBJECTIFS: Les objectifs de cette étude étaient i) d'effectuer une revue de littérature pour identifier les méthodes de quantification de la proprioception de l'épaule utilisées en laboratoire et en clinique et d'en présenter les qualités métrologiques, ii) d'évaluer l'efficacité d'un programme d'entrainement neuro-musculaire en comparant son efficacité à réduire la douleur à l'épaule et en améliorer la fonction à celle obtenue par des soins usuels de physiothérapie. MÉTHODES: i) Une revue de 5 bases de données a été conduite d'octobre 2015 à juillet 2016 pour documenter les propriétés métrologiques de protocoles d'évaluation de la proprioception à l'épaule. Les études incluses ont été évaluées à l'aide de l'outil de contrôle QualSyst et de l'échelle COSMIN à 4 points. ii) Trente-trois soldats en service actif au sein des Forces armées canadiennes ont été assignés au hasard à 1) programme standardisé supervisé d'entrainement neuromusculaire et contrôle moteur (Exp) ou à 2) soins usuels de physiothérapie (Ctl). Les variables principales étaient les symptômes, la capacité fonctionnelle et les limitations physiques évalués avec le questionnaire Disabilities of the Arm, Shoulder and Hand (DASH) et la variable secondaire était l'indice Western Ontario Rotator Cuff (WORC). Toutes les variables ont été mesurées au départ (T_0) et à 6 (T_6) et 12 (T_{12}) semaines après l'intervention. La comparaison des effets des interventions a été évaluée à l'aide d'une analyse per protocole (APP), analyse intention-traitement (AIT) et avec une analyse de variance à mesures répétées à 2 voies. RÉSULTATS: i) Vingt et une études (n = 407 participants, 553 épaules) ont été retenues. Les études analysées confirment d'excellents scores méthodologiques avec l'outil QualSyst (88,1 ± 9,9%) et de bons scores avec le COSMIN pour la fidélité (71,1%) et un score de qualité modérée à faible (50%) pour la validité de critère. Les coefficients de corrélation intraclasse (CCI) pondérés pour la fidélité intraévaluateur étaient les plus élevés pour le sens du positionnement articulaire passif et la kinesthésie soit 0,92 ± 0,07 (n = 214) et 0,92 ± 0,04 (n = 74), respectivement. Le mouvement et l'outil les plus fidèles sont la rotation interne à 90 ° d'abduction (CCI = 0,88 ± 0,01 (n = 53)) et le dynamomètre (CCI = 0,92 ± 0,88 (n = 225)). Aucune étude n'a rapporté d'indices de sensibilité au changement. ii) Aucune interaction significative ($p \geq 0,101$) de groupe × temps ($p \geq 0,101$) n'a été démontrée. Par contre, nous avons observé un effet de temps significatif ($p < 0,001$) pour le questionnaire DASH et l'indice WORC.

CONCLUSION: Ces données préliminaires suggèrent que les deux approches proposées conduisent à des améliorations comparables. L'utilisation d'une intervention de groupe axée sur l'exercice a le potentiel d'être aussi efficace qu'une approche un à un plus exigeante en terme de temps de traitement. Ces résultats permettront de fournir aux cliniciens des lignes directrices pour la mesure de la proprioception à l'épaule et l'utilisation d'une approche novatrice de traitement en groupe pour la TCR.

Mots clés: Épaule, tendinopathie, contrôle moteur, proprioception, programme d'exercices, soins en physiothérapie

ABSTRACT

INTRODUCTION: The shoulder is the most mobile joint of the body which means that it heavily relies of an important level of neuromuscular control at all times. A rotator cuff (RC) complex provides stability to the shoulder and often times falls victim to injury, which can produce functional limitations during activities of daily living and work tasks. Individuals affected by an RC tendinopathy often have neuromuscular and proprioceptive deficits. OBJECTIVES: The objectives of this study are to (i) conduct a systematic review to identify methods of quantifying shoulder proprioception in a laboratory and clinical setting and to present the associated psychometric properties. (ii) To evaluate the effectiveness of a novel neuromuscular training program for the upper extremities versus one-on-one physiotherapy care (manual therapy, range of motion exercises, strengthening) for the reduction of shoulder pain and improvement in function with soldiers affected by an RC tendinopathy. METHODS: (i) A review of five databases was conducted from conception to July 2016 to identify studies that reported at least one psychometric property of a shoulder proprioception protocol. The included studies were evaluated using the QualSyst checklist and the 4-point COSMIN scale. (ii) Thirty-three military personnel with the Canadian Armed Forces were randomly assigned to one of the following interventions: 1) Upper Extremity Neuromuscular Training Program; (2) usual physiotherapy care. The main outcomes included symptoms and functional capacity assessed using the Disability of the Arm, Shoulder, and Hand (DASH) questionnaire. A secondary outcome included the Western Ontario Rotator Cuff (WORC) Index. Outcome measures were evaluated at baseline (T_0) and 6 (T_6) and 12 (T_{12}) weeks post-intervention. The effects of the interventions were evaluated using repeated 2-way variance measures (ANOVAs) for a per-protocol analysis and intention-to-treat. RESULTS: i) Twenty-one studies were included, resulting in 407 participants and 553 evaluated shoulders (n). The weighed intraclass correlation coefficients (ICC) for intra-rater reliability were highest for passive joint position sense and kinesthesia, ICC = 0.92 ± 0.07 (n = 214) and ICC = 0.92 ± 0.04 (n = 74), respectively. The most reliable direction of movement and equipment used were internal rotation at 90° abduction, ICC = 0.88 ± 0.01 (n = 53), and the dynamometer, ICC = 0.92 ± 0.88 (N = 225). ii) No significant group ($p \geq 0.1$) or group × time interactions ($p \geq 0.1$) were found; though a statistically significant time effect ($p < 0.001$) was established for the DASH questionnaire and WORC Index. Our preliminary data suggests a marginally better improvement with the control group with all outcomes over 12 weeks. CONCLUSION: The evaluation of shoulder

proprioception is most reliable when using a passive protocol with an isokinetic dynamometer for internal rotation at 90° shoulder abduction. The preliminary results of our pilot RCT suggest that both groups statistically improved with a time effect, but that the usual care group further demonstrated clinically significant gains. The results of this study will provide clinicians with potential guidelines for measuring shoulder proprioception in a clinical setting, as well as an innovative approach to group therapy that is potentially less costly and equally as effective as conventional one-on-one physiotherapy.

Key words (4-6): Shoulder, tendinopathy, motor control, proprioception, exercise program, physiotherapy care

TABLE OF CONTENTS

LIST OF TABLES

TABLE CAPTIONS

TABLE 1: Minimal Physical Fitness Standards (MPFS) for universality of service for an active Canadian Armed Forces member. Retrieved from: http://www.forces.gc.ca/en/about-policies-standards-medical-occupations/op-def-performance-standards-minimum-tasks.page.

TABLE 2: Evaluation and intervention timeline with associated outcome measures for RCT.

TABLE 3: Statistical properties of clinical diagnostic tests for RC tendinopathy.

TABLE 4: The psychometric properties of the special tests and outcome measures used for the pilot RCT.

TABLE 5: Comparison of psychometric properties of different shoulder proprioception protocols for our systematic review.

TABLE 6: Means and standard deviations of baseline characteristics of the participants, according to intention-to-treat analysis (n = 33). Also presented are the results from the statistical analysis, demonstrating no statistical significant differences between the Ctl and Exp groups for their baseline demographics.

TABLE 7: Mean scores and standard deviations of DASH-CF and WORC-CF Questionnaires in relation to baseline values for the Ctl and Exp Groups (PPA n = 21, ITT n = 33) Data presented as mean change (± standard deviation). Δ Denotes a change from the baseline score (indicated at T_0 in bold) DASH: Disabilities of the Arm, Shoulder and Hand questionnaire (lower score indicates higher disabilities, therefore a negative change from baseline indicates an improvement); WORC:

Western Ontario Rotator Cuff index (higher score indicates higher functional capacity, therefore a positive change from baseline indicates an improvement).

TABLE 8: Mean scores and standard deviations of maximal voluntary isometric contractions (MVIC), expressed as muscle strength in Newton meters (Nm) of injured and healthy shoulder for the Ctl and Exp Groups at T_0 and T_6 (per-protocol analysis, n = 21 and intention-to-treat, n = 33). MVIC values reported in Newton-meters (Nm).
ABD: abduction, ER: external rotation. No statistically significant results have been found for a time or group × time interaction, nor for a group × time × shoulder interaction for either ABD or ER isometric strength.
†indicates a significant time effect ($P < 0.05$).

LIST OF FIGURES

FIGURE CAPTIONS

FIGURE 1: Scapulothoracic normalized kinematics of the shoulder complex.

FIGURE 2: Extrinsic and intrinsic mechanisms of a rotator cuff tendinopathy.

FIGURE 3: Effect size calculation for our pilot RCT.

FIGURE 4: Graphical depiction of the shoulder proprioception pathway. Proprioception includes bilateral symmetry with crossed representation. This suggests that proprioception information from the right side of the body is process in the somatosensory cortex in the left hemisphere.

FIGURE 5: An organogram describing the literature selection process according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement.

FIGURE 6: Weighted averages (WA) ICCs for intra-rater reliability of proprioception measures of the glenohumeral joint, except for PJMR for which a WA ICC could not be calculated. Columns without standard deviation (SD) bars represent data from a single study (s = number of studies included, n=number of shoulders evaluated).

FIGURE 7: Weighted averages (WA) ICCs for intra-rater reliability for various movements of the glenohumeral joint, except for Abduction (ABD) for which a WA ICC could not be calculated. Columns without standard deviation (SD) bars represent data from a single study (s = number of studies included, n=number of shoulders evaluated).

FIGURE 8: Weighted averages (WA) ICCs for intra-rater reliability for various proprioceptive equipment used for quantifying shoulder proprioception of the glenohumeral joint. Columns without standard deviation (SD) bars represent data from a single study (s = number of studies included, n=number of shoulders evaluated).

LIST OF ABBREVIATIONS AND COMMON TERMS

Abbreviation	Term
CAF	Canadian Armed Forces
MPFS	Minimum Physical Fitness Standards
AAOMPT	American Academy of Orthopedic Manual Physical Therapists
JPS	Joint position sense
MC	Motor control
RC tendinopathy	Rotator cuff tendinopathy
MSK	Musculoskeletal
UPC	Usual Physiotherapy Care
UpEx-NTP	Upper Extremity Neuromuscular Training Program
Ctl	Control group
Exp	Experimental group
RCT	Randomized controlled trial
SGHRP	Canadian Armed Forces Surgeon General Health Research Program
IR	Internal rotation
ER	External rotation
ABD	Abduction
SIS	Subacromial impingement syndrome
MDC	Minimal detectable change
MICD	Minimally important clinical difference
MVIC	Maximum voluntary isometric contraction
CID	Clinically important difference
SEM	Standard error of measurement
DASH	Disabilities of the Arm, Shoulder and Hand questionnaire
WORC Index	Western Ontario Rotator Cuff Index
GROC	Global rating of change scale
NPRS	Numeric pain rating scale

Pain: Pain is a complex pattern of sensory system activations that are intimately linked to the activity of other cortical systems including, but not limited to, the emotional, cognitive and modulatory processes.[1] It is important to note that not every trauma to tissues will result in the manifestation of pain.

Proprioception: Proprioception can be understood as our sixth sense,[2] through the gathering of internal sensory information through our peripheral and central nervous system. Proprioception has been defined as the awareness of, and ability to, sense the position of our limbs and trunk in space (position sense), as well as kinesthesia, the awareness of motion of the human body (motion sense).[3, 4] Proprioception is essential for well-adapted sensorimotor control. It fulfills the roles of feedback and feed forward sensorimotor control and consequently, the regulation of muscle stiffness, movement acuity, joint stability, coordination, and balance.[5]

Joint Position Sense (JPS): Joint position sense is a sub-modality of our conscious awareness of proprioception and refers to our ability to detect the positioning of our limbs and trunk within our surrounding environment.[6]

Neuromuscular control: Neuromuscular control is defined as a system of collaborative networks of the cerebral cortex, the spinal column, neurons and muscle fibers involved in the control of movement and posture.[7] Neuromuscular control further encompasses the efferent motor responses to sensory information, such as proprioception and kinesthesia. Neuromuscular control involves both a feed forward, planning of movements and preparatory muscle activity, and feedback mechanisms, which involve the regulation of muscle activity through reflexive pathways and top-down cortical commands.[8]

Neuromuscular training program: Neuromuscular training can be defined as "... training enhancing unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control".[9] In the case of the upper or lower extremities, it may include motor control, proprioceptive, and functional training.

Motor control: Motor control can be understood as the physiological mechanism behind how the peripheral and central nervous system produces purposeful, coordinated movements so that our limbs and trunk can interact with the rest of our body as well as our surrounding environment.[10]

Tendon: Tendons are mechanically loaded tissues that generally connect muscles to bone and are responsible for the tensile force transmission of muscle cells.[11]

Tendinitis: The inflammation of a tendon as a result of micro-tears when the musculo-tendinous unit is mechanically acutely overloaded with a tensile force.[12]

Tendinosis: Refers to the degeneration of the collagen within the tendon due to chronic overuse without an adequate healing period. This is generally the case with repetitive strain injuries.[12]

Rotator cuff (RC) tendinopathy: The progressive degeneration of a / several rotator cuff tendons[13] of the shoulder complex.

Shoulder impingement syndrome: A shoulder impingement syndrome refers to the dysfunctional biomechanics of the shoulder complex, which results in the physical pinching or encroachment of soft tissues (such as the tendons or bursae) under the acromion during shoulder movements.[14] The most common clinical signs of an impingement dysfunction include localized pain to the shoulder during elevation or overhead reaching, as well as positive clinical tests such as the Full Can, Empty Can, a painful arch, the lift off sign, and painful and weakened external rotation and abduction of the shoulder.[15]

To my devoted husband, Justin Christian Thibault
and my loving grandmother, Darling, to whom I owe everything.

ACKNOWLEDGEMENTS

Creating new knowledge requires the harmonious synchronization of many individuals and organizations. This project is of no exception and many thanks are due. Firstly, to my directors Luc J. and Jean-Sébastien, who guided me throughout two years of over ambitiousness. To the Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Laval University, and the Quebec Rehabilitation Research Network (REPAR) for their financial contributions, both through student bursaries as well as a research grant which allowed for the material realization of our rehabilitation project. To all the physiotherapists from the Valcartier Garrison (Quebec City, QC) who have believed in me from the very beginning, particularly France Gamache, Sophie Bernard, Pierre-Marc Vézina, Myriam Cyr, and Valérie Charbonneau, who all acted as the pillars to this project. A sincere thank you to Marie-Élise Prémont who is one of the hardest working people I know. Her role as an evaluator during the winter of 2017 allowed this project to continue to move forward during a difficult friction point. Lastly, to my cherished husband, Justin, who has supported me literally throughout our adventures around the world, and who will always be my infinite source of inspiration.

FOREWORD

The presentation of this thesis is the result of collective work performed by the Motor Control Laboratory at the Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS) / Institut de réadaptation en déficience physique de Québec (IRDPQ) as well as in collaboration with the Canadian Armed Forces Surgeon General Health Research Program and the Valcartier Garrison of the Canadian Armed Forces.

The aggregate of the scientific efforts has been compiled to form the basis for my Master's in Clinical and Biomedical Sciences (concentration in rehabilitation) through Laval University and under the supervision of my Director Dr. Luc J. Hébert and my Co-Director Dr. Jean-Sébastien Roy. The following overture is presented as a Master level thesis with the insertion of two articles, the first being a systematic review and the second being the results from our pilot randomized controlled trial, in the presentation of six chapters. The first chapter encompasses the introduction to the subject of shoulder pain, specifically caused by a rotator cuff (RC) tendinopathy, and the underlying biomechanical and motor control deficits that are associated with this disorder. The first chapter is further developed by exploring the scientific literature on the management of an RC tendinopathy as well as dissects the two possible approaches to shoulder pain management, specifically usual physiotherapy care (UPC) and an exercise-based group approach. The first chapter also explores the concepts of motor control and proprioception as it pertains to the rehabilitation efforts of the most mobile joint in the body, the shoulder. The first chapter concludes by introducing the overall aims of this thesis and presenting the objectives of our systematic review on shoulder proprioception and our pilot randomized control trial (RCT). The second chapter outline the methodology behind our pilot RCT. The third chapter offers the summation of our publication in the *Journal of Hand Therapy*, entitled Shoulder Proprioception, how is it Measured and Is It Reliable: A Systematic Review. The fourth chapter includes our recent manuscript submission: The Effectiveness of an Upper Extremity Neuromuscular Training Program on the Shoulder Function of Military Members with a Rotator Cuff Tendinopathy: A Pilot Randomized Controlled Trial to the *Journal of Military Medicine*. Chapters five and six finalizes our findings by presenting the ensemble of our discussion and conclusions while offering guidance to clinicians

for evidence-based rehabilitation for the management of a shoulder rotator cuff tendinopathy and the measurement of shoulder proprioception within a clinical setting.

I am the principle author of both articles as well as the sole author of said thesis. I fully participated in the theoretical inception, the development of the methodology, the collection of the data, the analysis, as well as the realization of the submitted manuscripts. The authors of the systematic review include my directors, as well as three collaborators, Marianne Roos, Amélie Fournier Belley, and Dr. Ann Cools from Ghent University in Belgium. The authors of the pilot RCT include my directors as well as a former colleague, France Gamache, PT, from the Valcartier Garrison who collaborated on the development and implementation of the Upper Extremity Neuromuscular Training Program. All authors made significant contributions to the development and achievement of the studies.

All information and studies presented are part of an overarching goal of bringing motor control and proprioception to the forefront of shoulder rehabilitation. This research was made possible by a collaborative student bursary between the CIRRIS and Laval University, as well as a research grant from the OPPQ-REPAR 4.2 program for clinical research.

CHAPTER 1

INTRODUCTION

1.0 The justification of our research

Our interactions with our surrounding environment greatly depend on our physical health. Reaching, pulling, and lifting, for example, are all activities that heavily rely on the health of our upper limbs, and of our shoulders in particular. Shoulder pain is one of the most common musculoskeletal (MSK) symptoms, with up to one-quarter of the Western population reporting a problem at any one time and up to two-thirds of all adults reporting pain over a lifetime.[16] Shoulder pain is the third most common reason to consult a physiotherapist,[17] but yet the management of shoulder pain and injuries are considered to be one of the most challenging areas of MSK medicine today.[18]

In Canada, statistics collected between 2009-2010 through the Canadian Community Health Survey (CCHS), found that among serious MSK injuries, involving a ligament, muscle sprain or strain, dislocations or fractures, 13.2% occurred at the shoulder, elbow, or the arm.[19] In most cases, muscle, tendon, or nerve injuries happen as a result of overuse or repetitive movements over an extended period of time. The shoulder complex is of no exception, acting as the leading site for repetitive strain trauma, accounting for 22.6% of all bodily strain injuries.[19]

The rotator cuff (RC) complex is one of the most common sites for shoulder injuries and is the leading cause for shoulder pain and physical impairments among an adult population.[20] This is exceptionally relevant to manual labourers engaged in repetitive movements of the upper extremities,[21, 22] which includes an active military population. It is well documented that such injuries of the shoulder can translate into significant time off work and a significant cost to the employer, both in terms of human resources and loss of productivity.[23] The military follows this trend, as shoulder injuries among soldiers are the fourth leading site for MSK injuries, leading to a medical discharge from active service.[24] Although studies have identified shoulder pain as being an important burden for a military population,[24-26] few studies have attempted to provide treatment guidelines for this specialized group.

There is currently an extend need for effective and efficient treatment approaches for shoulder disorders among serving military members. Although there are studies addressing neck and shoulder pain,[27] shoulder instability,[28] or post-operative repair among a military cohort,[29] to our knowledge, there are no treatment guidelines for the management of a shoulder rotator cuff tendinopathy or impingement syndrome for soldiers.

This project has the purpose of exploring the effectiveness of a supervised group-based exercise program in comparison to usual physiotherapy care for the management of a RC tendinopathy among active military service personnel. If the results suggest a comparable functional improvement between both treatment approaches, this could potentially spark a new discussion regarding the allocation of rehabilitation resources in terms of materials, time, and treating physiotherapists. This project has the potential to open a discussion regarding the efficiency and resource-effectiveness of a group approach for common MSK rehabilitation efforts across Canada.

1.1 The shoulder joint

The shoulder joint, anatomically understood as the glenohumeral (GH) articulation, is a very functionally important joint of the body. Being the most proximal joint of the upper extremity, the GH joint is involved in all upper quadrant movements and determines the success of our ability to execute movements involving our upper limbs to effectively interact with our environment. The GH joint does not act in isolation, but rather requires a complex choreography of surrounding joints, both active and passive structures, as well as the guidance from the nervous system to execute a purposeful motor task. For this reason, it is functionally more accurate to refer to the GH joint not only as the shoulder but as a shoulder complex, in order to be inclusive of the neighboring joints and structures that contribute to the coordinated movements of the shoulder and upper extremity.

The shoulder joint is known to be the most mobile articulation of the body,[30-32] with 360° of azimuth, it has 3 degrees of freedom, and consequently 6 movements within 3 anatomical planes. The shoulder complex is an important site for muscle attachment, with over 15 muscles[33] that act in-sync to allow us

to gainfully perform activities of daily living. The shoulder is heavily involved in common tasks such as reaching, pulling, pushing, and lifting.[34, 35] Often times, it is the gross motor movements of the shoulder that allow us to use our proximal joints for fine motor tasks such as preparing a meal, hygiene activities, sports and leisure, and even the menial task of typing on a computer.[35] Because of it's vast mobility and heavy implication in daily tasks,[34] the shoulder is a popular site for dysfunction and injury.

1.1.1 The prevalence, incidence, and etiology of shoulder pain

A shoulder injury can be functionally devastating to an individual, significantly impacting the most basic activities of daily living,[36] and can potentially place unnecessary financial stress on our health care system.[37] The actual etiology of shoulder pain is not fully known, but it is well known that shoulder pain is quite common and results in an annual incidence of shoulder disorders, ranging from 7 - 26% in a Western general population.[16]

According to the National Health Service and Society in the United Kingdom, approximately 1% of their population consults a medical practitioner with a new presentation of shoulder pain each year, which equates to an estimated cost of £310 million (an estimated $510 million Canadian) in health care related spending.[38] In the Netherlands, up to 50% of the cost associated with musculoskeletal (MSK) pain has been attributed to sick leave from paid employment.[39] Similarly in Quebec, a report of the *Commission de la santé de la sécurité du travail* (CSST), estimates that for the period of 2005-2007, the total annual expenses associated with shoulder disorders, including the human cost and those associated with lost of productivity from work, are estimated to be $393,204,738.[23, 40] Similarly, shoulder pain has been noted among Canadian Armed Forces military members, representing 14% of all reported MSK injury cases as well as being third in prevalence, tied with spinal injuries, and following closely behind ankle and knee injuries.[41, 42] We can therefore definitively concede that shoulder pain is a costly problem for both the civilian and military population.

Shoulder pain is currently among the most common reasons to visit a general practitioner or a physiotherapist today.[43] It is third in prevalence to back and neck pain[44] and nearly two-thirds of adults suffer from shoulder pain at some point during their lives.[20] A few commonly diagnosed shoulder dysfunctions include bicipital tendonitis, adhesive capsulitis (frozen shoulder), GH and AC arthritis,

instabilities and labral tears,[37] as well as an impingement syndrome (SIS) or a RC disorder.[15, 45] RC disorders, specifically a RC tendinopathy, is among the leading cause for medical consultation for shoulder pain.[20] The incidence itself of RC tendinopathies varies between 0.3% to 5.5%, with an estimated annual prevalence of 0.5% to 7.4%.[46] To best appreciate the potentially extensive limitations a shoulder injury can have on a person's quality of life, it is imperative to understand the intricacies of the underlying anatomy and biomechanics of the shoulder complex.

1.2 Anatomy and biomechanics

The shoulder complex involves 3 physiological joints, notably the glenohumeral (GH) joint, the acromioclavicular (AC) joint, the sternoclavicular (SC) joint, as well as a "functional joint" known as the scapulothoracic (ST) joint. The SC joint is the only bony attachment site of the upper extremity to the axial skeleton. The ST joint involves the gliding movement of the scapula along the rib cage during upper extremity movements and does not include a physical bone-to-bone attachment. The GH joint is of particular interest when understanding the mechanism of shoulder injuries because it is osteologically predisposed to instability.[47, 48] The GH joint is comprised of a ball and socket synovial joint, where the head of the humerus (convex surface) articulates with the glenoid fossa (concave surface) of the scapula. Because of the relatively large surface area of the humeral head in relation to the fossa, the joint itself has limited bony congruency, and consequentially heavily depends on surrounds soft tissues for structural support. Moreover, it is estimated that only 25% of the humeral head articulates with the glenoid fossa at any one time during movement.[49] The surrounding passive structures (the labrum, joint capsule, and ligaments) as well as the active structures (the muscles and associated tendons) act cooperatively in a healthy shoulder to maintain dynamic stability throughout movement.

An area most often involved in the cases of shoulder pain is the subacromial space, which includes the theoretical space between the coracoacromial arch and the head of the humerus.[13, 50] More specifically, the subacromial canal lies underneath the acromion, the coracoid process, the AC joint and the coracoacromial ligament.[51, 52] The space itself includes a bursa which provides lubrication for the RC tendons, the insertion for the long head of the biceps tendon, and the RC tendons themselves.[13, 50-52]

1.2.1 Static structures and mechanoreceptors

The static structures of the shoulder complex, which includes the labrum (a fibrocartilaginous ring), the capsule, cartilage, ligaments, and fascia collectively act as the physical restraints to the osseous matter and provides a deepening effect to the shallow glenoid fossa.[53] Further to their passive stabilization role, they also provide additional protection via the various mechanoreceptors embedded within their fibers. Mechanoreceptors can be understood as the neural sensors that provide afferent input to the central nervous system for motor processing and descending motor commands for the execution of movements.[54-56] Mechanoreceptors are characterized by their specialized nerve endings that are sensitive to the mechanical deformations of tissues,[57-59] and therefore contribute to the modulation of motor responses of the adjacent muscles. Mechanotendinous receptors (muscle spindles and golgi tendon organs), capsuloligamentous receptors (ruffini and pacinian corpuscles) as well as cutaneous receptors (meissner, merkel and free nerve endings) are responsible for our sense of touch, vibration, proprioceptive positioning, as well as provide the feedback regarding muscle length, tension, orientation, further to the speed and strength of the contractions of the muscle fibers.[47, 60] It is therefore, resoundingly clear that the passive structures of the shoulder provide a neurological protection mechanism through feed forward and feedback input, that directly mediates reflex musculature stabilization about the glenohumeral joint.[55]

1.2.2 Shoulder musculature

Further to the intricate network of passive ligatures that conjoin adjacent bones, the importance of the surrounding musculature cannot be overstated. Active muscle contractions are essential for maintaining the stability of the shoulder complex.[47] The musculature of the shoulder region can be subdivided into the global movers of the shoulder and the fine-tuning stabilizers of the individual articulations. The larger muscles such as the trapezius, the levator scapula, the pectorali, the deltoids, the serratus anterior, the latissimus dorsi, the rhomboids, the teres major, the biceps, the coracobrachialis, and triceps muscles are responsible for various synergistic activities during shoulder movements. Conjointly as agonist and antagonist couplings, they allow for the gross motor movements of the upper quadrant. More specifically to the GH joint, the fine-tuning stabilizers are just as important to the shoulder complex as the global movers for coordinated and smooth shoulder movements.

The stabilizing muscles of the GH articulation, the supraspinatus, subscapularis, infraspinatus, and teres minor, are often summarized as the rotator cuff (RC) complex, and attach to the humeral head within the glenoid fossa. Collectively, they act as the dynamic stabilizers of the GH joint by maintaining a centralized positioning of the humeral head within the glenoid fossa,[61, 62] in both static and dynamic conditions. It has been suggested that the tendons of the rotator cuff muscles blend with the ligaments and the glenoid labrum at their respected sites of attachments, so that the muscle contractions can provide additional stability by tightening the static structures during movement.[63] The synchronized contractions of the RC muscles must maintain the centralized positioning of the humeral head during movements in order to avoid the physical encroachment of tissues, predominantly anteriorly or superiorly to the GH joint, which has been linked to injury and pain amongst the shoulder region. As previously noted, due to the anatomical passage of the common RC tendon within the subacromial space, the RC tendons are particularly vulnerable to compression, abnormal friction, and ultimately an impingement (pinching) during active tasks.[13, 50] Proper alignment of the glenohumeral head is important for the healthy engagement of the shoulder joint in activities of daily living.

1.2.3 Biomechanics of shoulder movement

To further grasp the contributing factors of shoulder pain and associated dysfunctions, it is essential for researchers and clinicians alike to understand the biomechanics of the shoulder complex. In the interest of a specific injury of the shoulder, notably the rotator cuff (RC) tendinopathy, the biomechanics of the GH and ST joints will be discussed within this section.

The natural arthrokinematics of the GH joint of the shoulder complex during an open-chain movement supports various directional glides of the humeral head within the glenoid fossa.[64, 65] Del Maso and colleagues have estimated that a maximum of 7.5 mm of upward translation of the humeral head may occur during range of motion movements,[65] which is not an insignificant amount of migration for a large bony structure to experience within a compact space during a dynamic task. The success of a coordinated movement of the humeral head with normalized arthrokinematics, avoiding an impingement situation, requires the harmonious co-contraction of the RC tendons. Abnormal glenohumeral translations have been linked to pathological shoulders and it has been suggested to be a contributing factor for shoulder pain and discomfort, and may also lead to the damage of encompassing structures.[65, 66]

As illustrated by the force-vectors of their respected moment arms, the RC tendons collectively have been accredited with the compression of the humeral head within the glenoid fossa during movements.[67] The individualized tendons of the RC complex are directly affiliated with limiting the translation of the humeral head in specific directions. The supraspinatous muscle contributes to preventing excessive superior translation, the infraspinatus and teres minor limit excessive superior and posterior translation, and the subscapularis controls excessive anterior and superior translation of the humeral head, respectively.[68] An imbalance in the neural activation of any one of the RC muscles could easily cause a misalignment of the humeral head thus giving rise to an impingement of the subacromial structures during movement. Both the superior and anterior translation of the humeral head during movements are the leading biomechanical causes for an impingement syndrome,[69] and a contributing factor to the development of a rotator cuff tendinopathy.[65, 66, 69]

The movement of the scapula along the thoracic cage also directly influences the biomechanics of the shoulder complex as a whole, and can moreover predispose the development of an impingement syndrome. The healthy movement of the scapula along the thorax during arm elevation includes protraction, posterior tilting and lateral rotation, depending on the plane of movement (Figure 1).[70-73]

FIGURE 1

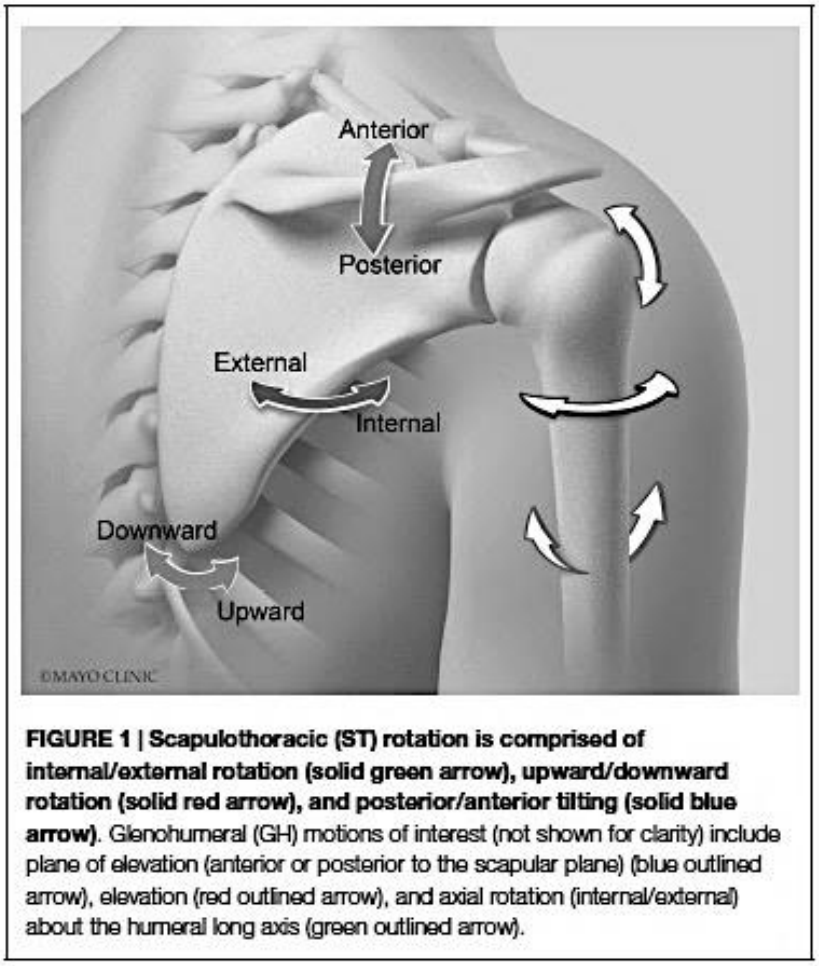


FIGURE 1 | Scapulothoracic (ST) rotation is comprised of internal/external rotation (solid green arrow), upward/downward rotation (solid red arrow), and posterior/anterior tilting (solid blue arrow). Glenohumeral (GH) motions of interest (not shown for clarity) include plane of elevation (anterior or posterior to the scapular plane) (blue outlined arrow), elevation (red outlined arrow), and axial rotation (internal/external) about the humeral long axis (green outlined arrow).

Figure 1 Caption: Scapulothoracic normalized kinematics of the shoulder complex. Retrieved from Zhao et al. 2015.[74]

Although posterior tilting is generally understood as primarily an acromioclavicular joint motion, the tilting that occurs at the scapula during arm elevation is crucial in order to minimize the encroachment of soft tissues passing under the acromial arch.[73] The normal contribution of the ST joint is generally expressed as the ratio of ST movement with regards to that occurring simultaneously at the GH articulation. The scapulohumeral rhythm is quantified by dividing the total amount of shoulder elevation (humeralthoracic) by the scapular upward rotation (scapulothoracic).[70] Within the scientific literature, the scapulohumeral rhythm is generally accepted to be 2:1, which represents 2° of humeral elevation for every degree of scapular upward rotation.[71, 75, 76]

The stability of the ST joint relies on the coordinated activity of the 18 muscles that directly attach to the scapula.[77] The scapular muscles must dynamically control the positioning of the glenoid so that the humeral head remains centered and permits arm movement to occur. When a weakness or neuromuscular dysfunction of the scapular musculature is present, normal scapular arthrokinematics become altered,[76] and ultimately predisposes an individual to an injury of the GH joint.[75-77] The pathological kinematics of the ST joint include, but are not limited to 1) increased medial rotation, 2) decreased superior rotation and 3) decreased posterior tilting[74, 78, 79] These movement alterations are believed to increase the proximity of the rotator cuff tendons to the coracoacromial arch or glenoid rim,[73, 80] however, there are still points of contention as to how the movement pattern deviations directly contribute to the reduction of the subacromial space.[73] For the sake of clarification, the current literature differentiates between an internal impingement and an external impingement. An impingement that involves a decreased space towards the coracoacromial arch is said to be an external impingement, whereas an internal impingement involves the glenoid rim,[73] and can be associated with a GH instability.[81] Regardless of the classification, the dysfunctional shoulder mechanisms can further the progression of rotator cuff disease[82] and must therefore be understood as a neuromuscular impairment.

The neuromuscular control of the scapula relies on the balanced team-work between the global movers and the fine-tuning stabilizing muscles of the shoulder complex. Again, because of the floating nature of the scapula along the thorax, it too, must rely on the kinship between the cortical direction provided by the nervous system and the resulting action of the MSK system. We can therefore affirm, that the shoulder complex is among the most kinematically complex regions of the human body,[80] and requires a high level of neuromuscular stability throughout movement. The neuromuscular control of the shoulder also requires a well-developed sense of motor control and proprioception.

1.3 Motor control and proprioception

For the purpose of this thesis, motor control can be defined as the ability of our peripheral nervous system (specifically, our mechanoreceptors, sensory receptors, and neural relay pathways) and our central nervous system (spinal and cortical processing) to produce purposeful, coordinated joint movements to facilitate internal interactions (of our limbs and body) and external interactions (our environment) for every day life.[10] It is a process that varies in complexity from a reflexive spinal loop, to higher processing neural networks that involve cortical control. In the case of the shoulder complex, it involves using all

senses to produce normalized and non-pathological movement patterns. The complex nature of the shoulder joint implies that numerous muscles must act together to provide both stability and motion.[75-77, 83] Moreover, the normalized mechanism of the shoulder complex involves the input from the nervous system, both peripherally and centrally, to successfully interact with our environments and sustain from injury.

Dynamic stability of the shoulder joint requires highly attuned motor control and an intact sense of proprioception. Proprioception is a concept that is associated with motor control, but should not be misunderstood as representing the same physiological concept. Proprioception is accredited with being our sixth sense,[2] and can best be appreciated as our ability to detect the position of our trunk and limbs in space in the absence of visual feedback.[3] Proprioceptive input is collected by the mechanoreceptors located within our passive, dynamic, as well as cutaneous tissues, and is sent via the posterior column-medial lemniscus pathway (PCML) for higher processing within the postcentral gyrus and cerebral cortex.[84] Descending commands from the motor cortex directs the neuromuscular synchronicity about an articulation for purposeful and (motor) controlled movements. As noted by Clark and colleauges,[5] both proprioception and motor control are absolutely essential for a well-adapted sensorimotor control, particularly with regards to highly mobile joints such as the shoulder. Proprioceptive feedback facilitates shoulder motor control by regulating muscle stiffness, movement acuity, joint stability, coordination, and balance.[5] It further contributes to motor control by providing sensory feedback for inter-limb coordination,[85, 86] correcting and updating movement strategies,[87] and for the formation of muscle synergies.[88,89] Proprioception is the sensory input that helps the nervous system implement efficient and effective motor strategies for healthy movement.

Motor control and proprioceptive deficits have been associated with MSK injuries[90-95] and have also been linked to the recurrence and persistence of physical impairments such as shoulder pain, decreased range of motion and strength.[91, 95, 96] As outlined by Contemori & Biscarini,[90] deficiencies in afferent proprioceptive information may results in the poor accuracy of descending motor commands and impairment of the shoulder neuromuscular function, leading to reduced shoulder functional stability, and ultimately an increased risk of injury. Furthermore, proprioception and motor control have been recognized as being disturbed among MSK disorders due to pain, effusion, trauma, and fatigue,[5] all of which frequently occur within the scope of a shoulder injury. More precisely, it has been well

documented that individuals affected by an RC tendinopathy or SIS often exhibit motor control[97, 98] and proprioceptive deficits.[95, 99, 100]

1.4 Rotator cuff tendinopathy

Among shoulder disorders, the RC tendons are the leading source of shoulder pain.[99, 101-103] Due to their role in providing dynamic joint stability, they are often highly susceptible to injury.[13, 104] Like any tendon, the RC tendons can become pathological due to several mechanisms, but most commonly, it is the result of a shoulder mechanical impingement. A RC tendinopathy is commonly referred to as a subacromial impingement syndrome (SIS),[104] however, it is important to note that despite the use of the term "impingement" in a diagnostic capacity, a RC impingement is a clinical sign, not a diagnosis.[61, 105] To best understand the biomechanics behind the concept of a SIS, it is important to outline both the intrinsic and extrinsic factors that contribute to the possible irritation or degeneration of the RC tendons. Although the exact pathophysiological etiology of the RC tendinopathy is not entirely clear,[61] there is a growing consensus that an impingement occurs when the RC tendons, collectively passing within the subacromial space, are subjected to repetitive stresses such as pinching, most often caused during repetitive overhead activities.[106] The RC tendons become "pinched" within this space during movements among individuals with decreased shoulder girdle motor control, consequently causing irritation, swelling and damage to the tendons.[61, 106] The exact pathophysiological reasoning behind the changes to the tendons or the subarcromial space is not currently known.[61] For the purpose of this thesis, a RC tendinopathy will refer to the clinical presentation of a collection of cluster signs and symptoms, determined by clinical diagnostic tests, which suggest an underlying degeneration of the tendons or a compression of subacromial structures (the RC tendons, the bursa, and / or the long head of the biceps tendon). An RC tendinopathy can be provoked by either a trauma or an impingement mechanism. It is important to note that not every person with a clinical diagnosis of tendinopathy will experience shoulder pain.[104] Because there is currently a poor understanding of the source of pain in an RC tendinopathy, shoulder pain alone cannot be the only clinical indicator of a pathology.

1.4.1 Classification of tendon injuries and contributing factors

The terms tendinitis, tendinosis, and tendinopathy are often used synonymously by researchers and clinicians.[45] In recent scientific trends, greater emphasis has been placed on improving the precision of tendon injury taxonomy. It has become increasingly important for both researchers and health care providers to systematically define the source of the injury so that the underlying mechanism can be correctly identified, and subsequently successfully treated. A tendinopathy is an overarching term which indicates damage, and at times pain, in and around the tendons.[107] The term encompasses both a tendinitis and a tendinosis. For precision sake, a tendinitis traditionally refers to the acute inflammation of the tendon,[12] whereas the tendinosis refers to the separation and degeneration of collagen bundles of the tendons due to repetitive and often long-term stresses.[12, 108] Controversially, basic scientific research suggests that factually, little to no inflammation, is present among these tendon conditions.[107]

1.4.2 Intrinsic factors

The intrinsic factors of a RC tendinopathy are known to be associated with the degeneration of the tendinous tissues.[109] As outlined by Seitz and colleagues,[109] the intrinsic factors include pathophysiological elements such as tendon vascularity, morphology and composition, as well as the natural biology or genetics of a person. Khan and colleagues[110] have also suggested that intrinsic factors should include the resultant effects of an acute or traumatic event, such as inflammation, which can potentially provoke pathophysiological changes to the involved tissues.

Inflammation and degeneration of a tendon can also occur from excessive loading. Excessive loading occurs when external forces exerted on the soft tissue exceeds its maximal tolerance, thus causing micro-tearing over time. Tendons are load bearing structures and their main role is to transmit forces from muscle to bone. Loading is essential for maintaining tendon homeostasis, however excessive loading can lead easily led to degeneration and tearing.[111] This resultant mechanism of overloading can encourage the RC tendons to become pathological with overuse and repetitive activities.[112]

1.4.3 Extrinsic factors

The extrinsic factors of a RC tendinopathy are defined as those that cause a compression of the RC tendons.[109] The compression is linked to the narrowing of the subacromial space,[106] which could be due to an excessive angulation of the acromion,[106] a type II or III acromion morphology,[110] inadequate stabilization of the scapula,[113] abnormal shoulder kinematics,[80, 114-116] specific muscular weaknesses (rotator cuff, serratus anterior), or muscular tightness / shortening (pectoralis minor which pulls the scapula into a protracted position),[61] globally resulting in a RC and/or scapular muscles performance deficit.[80, 117, 118] This inadequate scapulothoracic muscle control is believed to contribute to a reduction in amplitude in posterior tilting and lateral rotation of the scapula,[80] which causes the acromion to remain in a lower anterolateral position resulting in a dynamic narrowing of the subacromial space.[97, 119] It is also noted that the elevation of the humeral head may provoke an imbalance between the humeral head elevators (deltoid muscle) and the stabilizers (notably the rotator cuff muscles). This noted imbalance may encourage a superior migration of the humeral head,[106] consequently further narrowing the space for the passage of the RC tendons and resulting in further damage to the tissues.[97, 119] Along the same resultant biomechanics of the superior or anterior migration of the humeral head, a shoulder impingement can sometimes be associated with a shoulder instability,[120] where individuals exhibit hypermobility and significant capsular laxity,[62, 121] furthering the mobility of the humeral head and encroaching on the subacromial space. Collectively, these deficits contribute to the impingement of subacromial structures and often lead to the symptoms associated with a RC tendinopathy. More often than not, the underlying mechanisms of a RC tendinopathy can best be understood as a combination of both intrinsic and extrinsic factors[61, 109] (Figure 2).

FIGURE 2

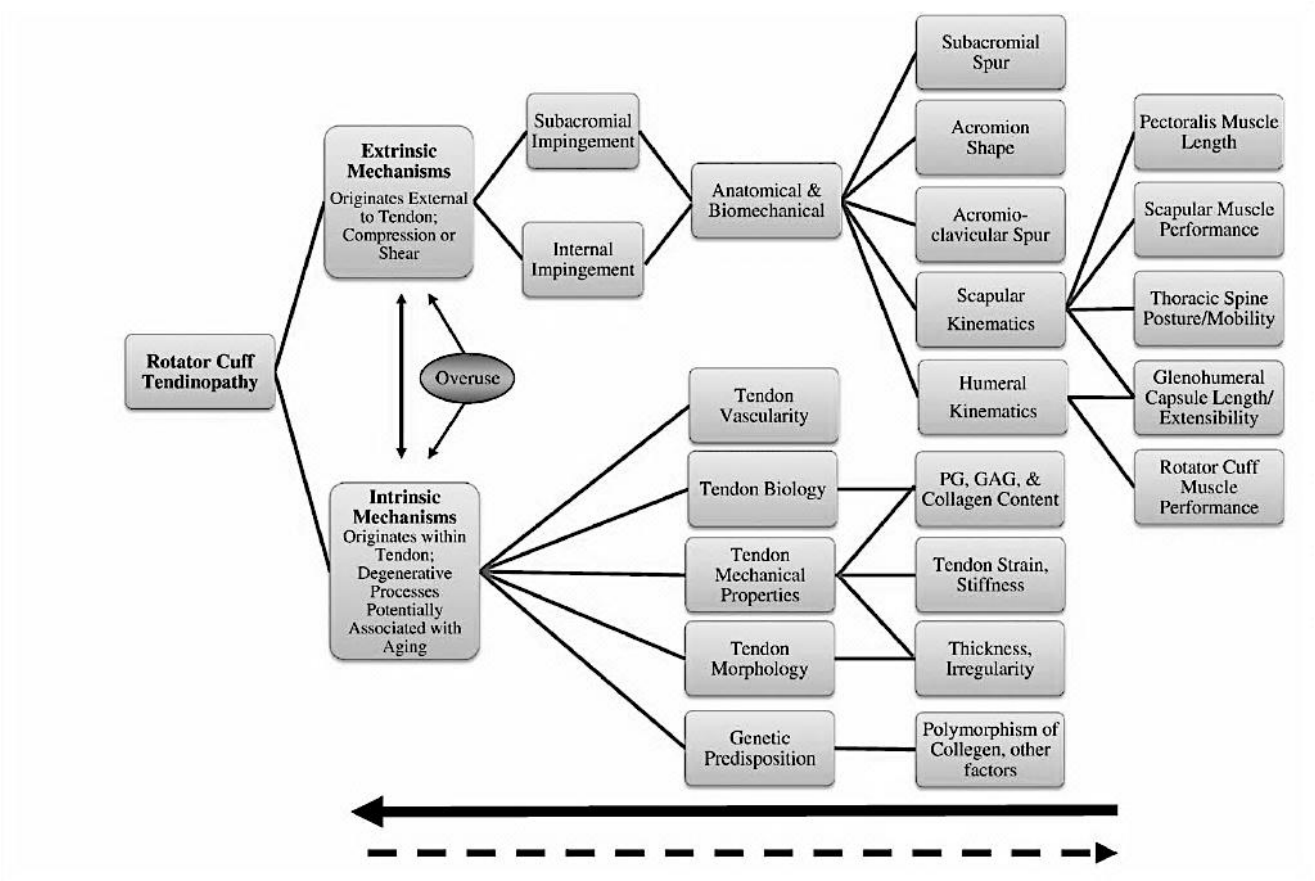


Figure 2 Caption: Extrinsic and intrinsic mechanisms of rotator cuff tendinopathy. Lines indicate non-directional evidence of these relationships, as described by Seitz et al. (2011).[109]

1.4.4 Cortical influence and central sensitization

Further to the peripheral mechanisms of a tendinopathy, there is also growing support for a possible central cortical component. It is becoming increasingly recognized that a shoulder tendinopathy can be associated with pain radiating down the arm, cutaneous hypersensitivity,[122] as well as bilateral upper extremity symptoms,[123, 124] which could suggest changes to the central nervous system, or central sensitization. To support this theory, a study by Ngomo and colleagues noted a decreased in the corticospinal excitability of the infraspinatus muscle of the shoulder with an RC tendinopathy compared to the uninjured shoulder,[125] suggesting central adaptations to the nervous system associated with the injury. This is important to understand for rehabilitation purposes, because the management of a RC tendinopathy should therefore include both the management of the local problematic biomechanics of the shoulder, but should also address the cortical reorganization of the shoulder region. The following

section will outline current rehabilitation practices for the management of an RC tendinopathy, with an introduction to our population of study, active military members.

1.5 Military members and shoulder injuries

The military population was chosen for our study due to a soldier's high susceptibility to MSK injuries[41, 42, 126] and because rehabilitation occurs in a very unique context. Soldiers are expected to maintain a high level of physical fitness and must recover quickly and effectively from their injuries in order to maintain operational readiness. Canadian soldiers who cannot meet the minimal physical standard, known as the Test Force (See Table 1), are put on medical restrictions, which could potentially lead to a medical discharge from active service. Physical health is an integral part of a Canadian Armed Forces (FAC) member's career.

TABLE 1

Functional Task	Minimum requirements for a pass
1. Sandbag Lift	30 consecutive lifts of a 20 kg sandbag from the floor above a height of 1.0 m. The member alternates between left and right sandbags separated by 1.25 m. To be completed in 3 minutes and 30 seconds.
2. Intermittent Loaded Shuttle	10 consecutive shuttles (1 shuttle = 20 m there, 20 m back), alternating between loaded shuttles with a 20 kg sandbag and unloaded shuttles, totalling 400 m. To be completed in 5 minutes and 21 seconds.
Sandbag Drag	Carry one 20 kg sandbag and pull a minimum of four on the floor over 20 m without stopping. Number of sandbags being dragged depends on the type of floor. No minimum time limit.
20 Meter Rushes	Starting from the prone position, complete two shuttle sprints (1 shuttle = 20 m there, 20 m back) dropping to the prone position every 10 m for a total of 80 m. To be completed in 51 seconds or less.

Retrieved from: http://www.forces.gc.ca/en/about-policies-stan dards-medical-occupations/op-def-performance-standards-minimum-tasks.page.

Table 1 Caption: Test Force: Minimal Physical Fitness Standards (MPFS) for universality of service for an active Canadian Armed Forces member.

Physiotherapy within a military context must be efficient, effective, and allow the member to return to optimal physical capability for mission readiness.[127] For this reason, the approach and interventions of our project have been specifically designed for a military population. Our interventions have been framed

within the realities of a military context, which equates to more difficult and functional exercises, parameters that encourage endurance, as well as a time-frame that optimizes a rapid return to operational readiness for the member.

Because of the level of physical fitness required to perform basic soldier duties, military members are often characterized as highly trained athletes. Although there are comparable features between the two populations, the reality remains that military members need to be functionally fit and agile in a variety of environments. As such, military members often fall victim to MSK injuries, whether they be acute from a traumatic event or chronic repetitive-strain injuries. Interestingly enough, the majority of the MSK injuries are not caused by military exercises or combat missions, but rather are non-combat related injuries brought forth by sporting activities or physical training.[24, 25] As astutely reported by Hébert (2016),[24] MSK injuries are a not only a hindrance to the health and wellbeing of the CAF, they also represent a significant cost for military healthcare expenditures. To offer further perspective, within a United States context, MSK injuries remain the number one reason for military personnel to seek medical care. Nonfatal injuries (which include MSK injuries) result in almost 25 million days of limited duty (sick leave or modified work restrictions) annually.[128, 129] In Canada, both the 2010 and 2014 Surgeon General's Medical Reports, indicate that MSK injuries are responsible for between 43% and 66% of medical releases from the CAF for members who were considered disable, unfit to perform their duties, or otherwise unemployable by the military.[130, 131]

The shoulder is among the leading sites for MSK injuries for active military personnel.[41, 132] Despite being identified as an important source of pain and injury, the exact prevalence and profile of shoulder injuries among a military population is currently unknown.[28] Moreover, to our knowledge, the etiology and prevalence of a shoulder RC tendinopathy, specific to a military population, remains to be clearly identified. What is known, is the devastating effect that a shoulder injury can bring to a soldier, in terms of the longevity of their career, quality of life, and ultimately their livelihood. Because of the nomadic nature of a soldier's work environment, establishing an efficient and effective physiotherapy treatment plan for shoulder injuries remains a challenge to this day. The following section will outline the current rehabilitation efforts for the management of a RC tendinopathy.

1.6 Physical rehabilitation for a rotator cuff tendinopathy

Currently there is no resounding consensus as to how shoulder pain should be treated in a rehabilitation setting.[133] The current non-operative trends include a combination of modalities,[134, 135] stretching,[136] manual therapy,[137-139] acupuncture techniques,[140] and exercise prescription for strengthening and motor control of the surrounding musculature.[141-144] The literature currently favors a combination of treatment approaches,[135, 141, 145] depending on the presented etiology and symptomology of the patient. There is no clear-cut rehabilitation pathway for addressing shoulder pain,[35] which also includes the management of a RC tendinopathy. Traditionally, a RC tendinopathy has been addressed by a combination of physiotherapy, the prescription of non-steroidal anti-inflammatory drugs (NSAIDs), and as a last resort, surgical intervention.[146] Physiotherapy is often the first line of defense for a RC tendinopathy,[147] but a clear set of clinical guidelines for treatment over time has yet to be well established. The following sections will outline the scientific evidence for the various physical therapy approaches currently being practiced by clinicians for the management of a RC tendinopathy.

1.6.1 Acupuncture and electro modalities

Acupuncture and electro modalities such as ultrasound, transcutaneous electrical nerve stimulation (TENS), pulsed electromagnetic field therapy (PEMF), microcurrent electrical stimulation (MENS), acetic acid iontophoresis and microwave diathermy, as well as shockwave therapy, are common physiotherapy treatments used to induce a localized analgesic effect for shoulders affected by a RC tendinopathy. Recent systematic reviews[148, 149] reported no significant differences between acupuncture and a placebo for short-term shoulder improvement, and found very limited evidence concerning the effectiveness of acupuncture for improving pain or shoulder function over time.

Along the same vain, the effects of electrophysical agents among patients with a RC tendinopathy were explored in a systematic review by Page and colleagues (2016),[135] which included 47 trials and 2388 participants. Due to the low quality evidence and poor statistical power, it is unclear whether therapeutic modalities provide additional benefits to the management of a RC tendinopathy. There may be evidence to support the use of pulsed ultrasound for short-term benefits in individuals with calcific rotator cuff tendinitis, but further high quality placebo-controlled trials are needed to support these results.[135] Further support for the discontinuation of electro modalities for a rotator cuff tendinopathy comes from Desmeules and colleagues, who found no additional benefit when using ultrasound for the management of pain or functional gains among this population.[150] Moreover, their systematic review from 2016

investigating the effectiveness of TENS for the treatment of RC tendinopathy found that no definitive conclusions can be drawn because of the limited number of studies available and a possible high risk of bias with the studies included in their review.[151] So overall, the literature is currently ambiguous with regards to the effectiveness of acupuncture or therapeutic modalities with respect to any long-term functional benefits or added effect when combined with exercise programs,[149] for individuals affected by a rotator cuff dysfunction.

1.6.2 Stretching and range of motion exercises

Stretching efforts among individuals affected by a RC tendinopathy are generally focused on the surrounding musculature and fascia within the cervical and shoulder area,[136] or a tight glenohumeral capsule.[152] Musculotendinous units of the pectoralis muscle group and the rotator cuff muscles are often targeted for stretching because they have been theorized to encourage a misalignment of the GH head within the glenoid fossa when taught.[153] Similarly, a tight posterior capsule can lead to a forward positioning of the GH head within the glenoid cavity[139] and further predispose an impingement of the structures within the subacromial space. Despite the scientific evidence for the use of stretching to be dated and mediocre at best, it is still a widely used practice among physiotherapists. Stretching techniques can be static or dynamic and are often achieved through manual therapy techniques.

1.6.3 Manual therapy

According to the American Academy of Orthopaedic Manual Physical Therapists (AAOMPT), manual therapy can be described as any "hands-on" treatments provided by a physical therapist.[154] The International Federation of Orthopaedic Manipulative Physical Therapists (IFOMPT), furthers the understanding by stating that manual therapy includes "skilled hand movements intended to produce any of the following effects: i) improve tissue extensibility, ii) increase range of motion, iii) mobilize or manipulate soft tissues and joints, iv) induce relaxation, v) change muscle function, vi) modulate pain and vii) reduce soft tissue swelling, inflammation or movement restriction".[155] Manual therapy is a popular therapeutic tool for the management of a RC tendinopathy within a clinic, despite the mixed scientific support for its efficacy. A systematic review by Page and colleagues in 2016[145] summarized 52 studies that investigated the effects of manual therapy alone, or exercise alone, for the treatment of a RC tendinopathy. They found little to no evidence in patient-reported outcomes when either treatment,

manual therapy or exercise, was performed alone when compared to a placebo treatment. Furthermore, they concluded that manual therapy techniques provided few, or no additional benefits, when combined with other therapies, and that one type of manual therapy was rarely more effective than another. These findings are supported by another systematic review and meta-analysis that suggested that manual therapy may provide some pain relief, but it remains unclear as to whether it can improve function among adults with a RC tendinopathy.[156] Therefore, the effects of manual therapy on overall shoulder function and quality of life remains inconclusive.[133]

1.6.4 Exercise prescription

There is growing evidence to suggest that exercise-based therapies are the most efficient and cost-effective treatment approach for a RC tendinopathy.[146, 147] A systematic review conducted by Littlewood and colleagues (2013),[157] which summarized the results of 26 systematic reviews addressing conservative treatment approaches for the management of a RC tendinopathy, found that exercise, whether performed at home or in a clinic, appears to support superior outcomes over no treatment or a placebo effect. The authors further suggest that the evidence indicates that additional benefits may be gained with higher doses of exercise.[157] Although this may be encouraging results for the use of exercise prescription for clinicians, the optimal type of exercise and dosage remains unclear.[158] Furthermore, it is well understood that not all types of exercise will have the same effect for every patient.[157]

Holmgren and colleagues (2012)[158] performed a randomized control trial for the purpose of quantifying the effects of a specific exercise strategy, which included eccentric exercises and scapula stabilization exercises, to an unspecific movement exercise program for the neck and shoulder for individuals with SIS. Their results strongly encourage the use of a specific stabilization and eccentric loading exercise approach and found that only 20% of the exercise group continued to pursue a surgical intervention, compared to the non-specific exercise group, where 63% of the participants continued to hold their place on the surgical waiting list.[158] Echoing these results, two recent systematic reviews[159, 160] regarding the efficiency of exercise prescription for the management of a RC tendinopathy, concluded that exercise prescription is indeed, an effective and efficient therapeutic approach with an adult population.

Despite unclear guidelines on exercise type and dosage, the research consistently demonstrates improvements in symptoms and functional outcomes for patients with a RC tendinopathy who participate

in a well-structured and graduated exercise program.[104] Moreover, another unknown within the scientific literature, is whether the efficiency of the exercises are influenced by the delivery method, either one-on-one with a physiotherapist or within in a clinically supervised group setting. The following section will outline a specific exercise based approach for the management of a RC tendinopathy as well as present the support for a group-based supervised program.

1.6.5 Effectiveness of a structured program approach

The concept of a well structured exercise program for the treatment of common pathologies or conditions is beginning to surface within the scientific literature and the clinic alike. Although there are well established programs for post-surgical rehabilitation,[161] cardiovascular retraining,[162-165] as well as specific target groups such as the elderly,[166, 167] there is a latent establishment of programs for common MSK conditions within an outpatient or private rehabilitation setting. Currently, there are limited detailed documented protocols for MSK dysfunctions for the knee,[168-171] the thoracolumbar spine,[172] the cervical spine area,[173] and the wrist.[174] There is however, a growing body of scientific literature proposing a structured exericse-based model for the shoulder.[97, 138, 152, 175-178] It can be difficult to appreciate the full effectiveness of structured programs because the paramaters and duration are not always clear,[179] adherence may be a counfounding factor,[168, 177, 179] and the control groups widely vary between studies. For example, some studies have used the same pathological population for both the control and experimental groups,[138, 178-180] whereas other studies used healthy controls,[152, 181] and in some cases, a control group is absent all together.[97, 177] The lack of standardization and consequently, the difficulties in reproducting the protocols by other researchers or clinicians, limits the applicability of the structured programs. Furthermore, published results are currently presenting mixed results; where some studies are reporting greater favorable changes among the exercise group,[169, 172] some suggesting equal results between the exercise and control group,[168, 171, 173, 175, 178, 179] and another favoring better functional results with the control group, representing usual physiotherapy care in a clinic.[138]

Presently, structured exercise programs for RC tendinopathy appear to be the most popular among shoulder dysfunctions.[97, 138, 176-178] The current literature seems to support favorable results for a structured exercise program,[97, 138, 152, 176-181] however, the great variability that currently exists in terms of level of supervision (individual, group, or home-based), program parameters (frequency per week, length of program, series and repetitions of the exercises), and the performed exercises themselves, make

it difficult to pool the data or to extract clear clinical recommendations. Moreover, there is limited evidence to suggest which method of delivery, or level of supervision, is best suited for a structured-exercise based program for individuals with a RC tendinopathy.

1.6.6 Effectiveness of a group treatment approach

A group treatment approach for common MSK dysfunctions is an alternative mode of care that permits several patients with similar impairments and physical limitations to be treated at the same time. This approach in rehabilitation clinics could be both resource, and cost effective, as well as ultimately contribute to a significant reduction in health care spending.[182] Not only may this be a possible cost-efficient solution for rehabilitation clinics, it is also an approach that is generally favored by patients because it allows them to be actively engaged in their rehabilitation, as well as increase their motivation and compliance to treatment.[178, 183]

A study by Critchley et al. (2007)[184] investigated the effects of three delivery methods for physiotherapy treatments for low back pain, notably usual physiotherapy care, spinal stabilization classes, and physiotherapist-led pain management classes. Their results suggest that all three delivery methods improved all relevant health outcomes equally, but that the physiotherapist-led classes were the most resource-effective for health care services. Furthermore, it has been noted by Passalent et al. (2009) that a supervised group exercise-based approach is an effective solution for reducing waitlist time and subsequently increasing access to physiotherapy care.[185] Despite the economic arguments for the implementation of group exercise therapy, this has yet to be thoroughly explored for common MSK pathologies such as a RC tendinopathy. Although many studies outline various forms of structured programs, none of the mentioned studies to date employed a group-based approach as their delivery method. An interesting study by Caputo et al. (2017)[173] attempted to bridge this gap by evaluating the efficiency of a neck and shoulder strengthening group-based exercise program in the workplace for chronic neck pain using a video display unit (VDU). Although their study did not involve direct physiotherapy supervision of the exercises, they do suggest favorable outcomes for the group treatment approach. Despite few studies within the literature, there is emerging support for the delivery of rehabilitative care within a group setting.[173, 182-185]

1.6.7 Motor control and proprioceptive exercises

We can now appreciate that there is maturing support for a *specific* exercise strategy for the management of a RC tendinopathy. There is also scientific affirmation for a *structured* exercise-based approach, a *supervised* environment, as well as within a *group setting* for rehabilitation. The missing piece of the puzzle remains the best *type* of exercises for the management of a RC tendinopathy. If we return to the pathophysiological limitations associated with a RC tendinopathy, notably a decrease in motor and proprioceptive control of the shoulder complex, it is only intuitive to focus the rehabilitative care of an RC tendinopathy on the associated impairments.

It is well understood that individuals affected by a RC tendinopathy exhibit motor control and shoulder proprioception impairements,[97, 98, 109, 186] and can also adopt antalgic movements patterns and altered joint kinematics. More recently, it has been shown that direct damage to articular mechanoreceptors occurring via acute or chronic repetitive trauma, can result in proprioceptive deficits and sub sequentially lead to recurrent instability.[57] This is particularly pertinent for the shoulder complex because, as previously outlined, a functional instability can be a predisposing factor for the development of a RC tendinopathy. This dynamic, unfortunately creates a vicious cycle of mutual influence between symptomology and the underlying pathophysiological biomechanics of the shoulder region. As outlined by Ellenbecker & Cools (2010), the successful management of a RC tendinopathy involves correctly identifying the *underlying causes* of the kinematic dysfunction.[153] In the case of RC tendinopathy, the elementary motor control and proprioceptive impairments must be correctly identified by the treating clinician and addressed within the rehabilitation plan.

It is clear that the management of a RC tendinopathy should include motor control and proprioceptive exercises.[97, 98, 153, 187, 188] Several studies[97, 98, 152, 189-191] have substantiated the efficacy of motor control exercises on improving shoulder pain and function. As noted by Cools and colleagues,[187] rehabilitative training programs that focus on motor control are greatly needed for shoulder rehabilitation as well as to prevent re-injury in the future. Moreover, rehabilitation interventions should focus on motor (re)learning,[97] targeting a better muscle coordination to reduce motor control impairments,[97, 109, 119, 192] optimize movement control,[114, 116, 193] and improve muscle strength. [97, 119, 181, 192]

A study by Worsley et al. (2013),[98] examined the effects of scapular motor control retraining on young adults with SIS. They tested a 10-week motor control retraining package, focused on motor control exercises to correct the alignment and coordination of the scapula at rest and during movement, in addition to manual therapy techniques commonly used in clinical practice to manage symptoms. Their results found that the experimental group (motor control program) demonstrated improved impingement signs, function, and reduced pain immediately post-intervention. They suggest that the recovery mechanism involves a neurophysiological and biomechanical change to the shoulder complex, which is reflected in the muscle recruitment pattern and the optimized scapular kinematics.[98] Notwithstanding their support in favor of motor control exercises, the conclusions of their study are limited by the small sample size as well as the fact that the majority of the exercises were performed at home, without the supervision of a physiotherapist.

Similarly, a single-subject design study performed by Roy et al. (2009),[97] evaluated the effects of a 4-week supervised motor control and strengthening program on individuals with SIS. Eight subjects participated in three exercises sessions over 4 weeks, for a total of 12 sessions supervised by a physiotherapist. The interventions centered on proper scapulothoracic and glenohumeral alignment during arm elevation in the frontal, sagittal, and scapular planes. The exercises were progressed over 6 phases, to gradually introduce various levels of loads, speeds, and degrees of manual and visual feedback. The study encourages the preliminary introduction of motor control and strengthening exercises by promoting positive results with each participant with SIS, in terms of decreased shoulder pain and increased upper extremity function. Although very promising, the results of this study encourage further exploration, seeing as it was a single-subject design and did not incorporate a group dynamic for treatment.

The study by Worsley et al. and Roy et al. encourage clinicians to incorporate motor control and strengthening exercises into their clinical practice, but evidenced-based implementation remains cautious due to unclear guidelines in terms of parameters (series, repetitions, speeds, positioning), dosage (frequency of breaks, number of sessions per week), type of exercises (weight bearing, equipment, stability surface, resistance), level of supervision required (independent, physiotherapist assistant, physiotherapist), as well as the method of delivery (home, individual, or group setting).

The bottom line remains that there exists individualized support for an exercise-based approach, a structured and supervised approach, delivery within a group setting, and the use of motor control and strengthening exercises for the management of a RC tendinopathy. What is currently missing within the scientific literature is a study, which combines all of these aspects into one study. To our knowledge, there is currently no single study that has examined the effects of a supervised neuromuscular training program within a group clinical setting for the management of a RC tendinopathy.

1.6.8 The development of the Upper Extremity Neuromuscular Training Program

To address this current gap, we have developed a novel, structured, and supervised group exercise-based program focusing on neuromucular reeducation, including motor control and proprioceptive exercises, for the management of a RC tendinopathy for a military population. Our 6-week supervised group program allows patients to individually progress their exercises based on their symptoms, while being guided and corrected by the supervising physiotherapist. This model allows several patients to access physiotherapy services simultaneously, and potentially suggest a theoretically cost effective approach to rehabilitation.

Our program includes 11 stations, each representing a different group of exercises, with several variations and progressions of the same exercise in order to allow the participants to progress based on their ability and pain levels. The program was developed over a 2-year period through rigorous scientific research and clinical experience of the research team, working speficially with military members with an RC tendinopathy. The development and implementation of the program is outlined in detail in Chapter 2 of this thesis. The exercises of each station are thoroughly explained and demonstrated by the supervising physiotherapist during the initial treatment session. Techniques are consequently corrected throughout the 6-week program by the supervising physiotherapist. Participants attend the program 3 times a week for 6-weeks (up to 18 sessions), for a duration of 30-45 minutes each session, depending on their presenting symptoms.

What makes our approach unique in addressing RC disorders is the resource-effective exercise rehabilitation model we propose; a motor control and strengthening approach that is well supported in the scientific literature and packaged in a conveniently resource-friendly protocol. This approach maximizes patient autonomy while being matched to a suitable level of physiotherapist supervision.

1.7 Objectives

It has now been established that shoulder pain can be functionally devastating for a soldier and affect the operational readiness of military capability. Current rehabilitation efforts for the management of an RC tendinopathy are scientifically grounded in exercise prescription, specifically exercises that focus on motor (re)learning and proprioception for the shoulder complex. There is growing support for the delivery of exercises within a group setting.

1.7.1 The purpose of this thesis

Within this context, the purpose of this thesis was to investigate the effects of a newly developed 6-week group upper extremity neuromuscular training program (UpEx-NTP) compared to usual one-on-one physiotherapy care (UPC) for the management of a RC tendinopathy among military members, in the form of a pilot RCT.

Furthermore, within the larger context of the research efforts of the CIRRIS motor control laboratory, our aim was also to begin the ground work for understanding how shoulder proprioception is being quantified in a laboratory and clinical setting. In hopes of contributing to the discussion of measuring shoulder proprioception deficits associated with an RC tendinopathy, our goal was to perform a literature review on current methods and protocols for measuring shoulder proprioception and to present their psychometric properties in the form of a systematic review.

1.7.2 The overall objectives of this thesis:

1. Perform a systematic review on the current methods of quantifying shoulder proprioception (including the sub-sections of joint position sense and kinaesthesia) and report their associated psychometric properties.
2. Objectively evaluate pain and primary and secondary functional outcome measures of the shoulder between two groups (UpEx-NTP vs UPC) at week 6 and 12 post-intervention;
3. Explore the effectiveness of the group-setting intervention among active military members in terms of specific physical fitness military standards (The Test Force).

The subsequent sections will highlight the scientific questioning behind the pilot RCT and our systematic review.

1.8 Pilot randomized control trial

1.8.1 Scientific question

How will a 6-week UpEx-NTP improve pain, shoulder function and physical limitations among military members affected by a rotator cuff tendinopathy compared to usual physiotherapy care?

1.8.2 Statement of hypothesis

It is hypothesized that both the UpEx-NTP (Exp) and usual physiotherapy care (Ctl) groups will demonstrate statistically (p-value ≤ 0.05) and clinically (all noted changes above their MCID: DASH questionnaire = 11 points, .[194] WORC index = 12 points.[194] and the Numeric Pain Rating Scale for pain = 2 points) significant changes in shoulder pain, function and physical limitations over a 6-week period in individuals with an RC tendinopathy and will be maintained over time, notably 12 weeks after the intervention.

1.8.3 Specific objectives

The primary objective of this pilot RTC is to compare, in terms of pain, function and physical limitations, a group receiving a supervised rehabilitation program (UpEx-NTP) centered on strength and motor control training to a group receiving usual one-on-one physiotherapy clinical care (UPC) in military members affected by a RC tendinopathy of the shoulder. We will be assessing both self-reported and functional changes in both groups at baseline (T_0), 6-week (T_6), and 12 weeks post intervention (T_{12}). Our primary outcome measure is the self-reported Disability of the Arm Shoulder and Hand (DASH) questionnaire and our secondary outcome measures include level of pain, the Western Ontario Rotator Cuff (WORC) Index, maximum isometric strength of the external rotators and abductors of the shoulder, the perceived level of change questionnaire (GROC), patient reported satisfaction, as well as a military specific task, a repeated sand bag lift.

1.9 The systematic review

1.9.1 Research questions

1. What functional outcome measures currently exist to measure shoulder proprioception, both in a laboratory and clinical setting?
2. What psychometric properties (validity, reliability, responsiveness) are associated with the identified outcome measures?

1.9.2 Specific objective of the systematic review

To identify, summarize, and present the current psychometric properties (validity, reliability, and responsiveness) of outcome measures that quantify shoulder proprioception (including joint position sense and kinesthesia); in both a laboratory or clinical setting in adults with or without MSK disorders.

Chapter 2 presents the detailed methodology associated with our pilot RCT, whereas Chapter 3 and 4 presents the published methods and results for our systematic review on measuring shoulder proprioception and our pilot RCT, respectively.

CHAPTER 2

METHODOLOGY: PILOT RCT

2.1 Research protocol

In order to answer the primary objective of this thesis, a RCT (prospective experimental design) was performed with the ultimate goal of analysis of difference between the experimental and control groups over time. This RCT evaluated the primary and secondary outcome measures at 3 periods in time (week 0, week 6, and week 12) with active military members clinically diagnosed with a RC tendinopathy, currently stationed at the Canadian military base in Valcartier, Quebec. The physiotherapy department at the military hospital was the primary location for all screening, evaluations, treatments, and the 6-week reevaluation for all participants. The 12 week (T_{12}) post-intervention reevaluations was performed via questionnaires sent by e-mail or by a telephone interview.

2.2 Study design

This single-blind (evaluator), parallel-group RCT included three evaluation sessions (baseline (T_0), week 6 (T_6), week 12 (T_{12})) by the evaluators (Amanda L. Ager (ALA), Marie-Élyse Prémont, (MEP) or Valérie Charbonneau (VC)). All participants were recruited via medical referrals, through the physiotherapy department at the Valcartier Garrison or through recruitment posters (See Appendix A) placed within the military hospital and physical fitness facilities on the base. All participants were subjected to an initial telephone interview screening by an evaluator (ALA, MEP, or VC), at which point their suitability for an objective evaluation was established. Participants were excluded at this stage if they reported any neurological signs or symptoms of the upper extremities or cervicothoracic area, or if they have an obvious history of a traumatic shoulder sub-luxation or dislocation.

All objective evaluations took place in a secluded office, physically separated from the physiotherapy department. The participants were initially explained the general purpose of the study (without biasing their attitude towards one treatment option), and were explained the randomized nature of the study. All participants were given a written package explaining the details of the project (See Supplementary Appendix C) and were given the opportunity to ask questions before providing their written and informed consent for participation. Thereafter, the participants were subjectively and objectively evaluated for the project. Following the objective evaluation (90 minutes), the participants were randomly assigned (male

/ female blocked randomization) to one of the two intervention groups, the Experimental (Exp) or Control Group (Ctl), and would subsequently partake in their assigned 6-week intervention. The Exp group partook in the UpEx-NTP and the Ctl group received usual physiotherapy treatments. The exercise classes for the Exp group took place on the second floor of the hospital, whereas the usual care for the Ctl group took place in the Physiotherapy clinic on the first floor. The groups were distinctly separated and the usual care Physiotherapists were blinded to the content and parameters of the UpEx-NTP. See Table 2 for a detailed outline of evaluation sessions and treatment periods

TABLE 2

	WEEK 0 (T_0)	RANDOMIZATION	INTERVENTION	WEEK 6 (T_6)	WEEK 12 (T_{12})
DEPENDENT VARIABLE	Function Pain Strength			Function Pain Strength	Function
MEASURE	1. DASH 2. WORC 3. NPRS 4. Strength ER + ABD			1. DASH 2. WORC 3. NPRS 4. Strength ER / ABD 5. GROC 6. Satisfaction 7. Sand Bag Lift	1. DASH 2. WORC 3. GROC 4. Satisfaction
TOOL	Questionnaires HHD			Questionnaires HHD	Questionnaires

N.B. Independent Variable: (Intervention) i) Upper Extremity Neuromuscular Training Program (EXP) ii) Usual physiotherapy care (CTL).
Abbreviations: Disability of the Arm, Shoulder, and Hand (DASH) questionnaire, Western Ontario Rotator Cuff (WORC) Index, Numeric Pain Rating Scale (NPRS), External rotation (ER), Abduction (ABD), Hand Held Dynamometer (HHD) and Global Rating of Change (GROC) scale.

Table 2 Caption: Evaluation and intervention timeline with associated outcome measures.

To evaluate the effectiveness of blinding, the evaluators (ALA, MEP, and VC) completed a questionnaire related to their opinion of the allocation, after data collection. We chose to have two follow-up evaluations (week 6 in person, week 12 via e-mail) to determine the progression in the level of symptoms and functional limitations related to each of the intervention.

2.3 Participants

All participants were active military personnel (aged between 18 - 60) with a clinical diagnosis of RC tendinopathy. Participants were considered for this study if they presented with at least one positive finding in each of the following categories: 1) reported pain and / or stiffness to shoulder joint, localized tenderness over one of the rotator cuff muscles, reported night pain to the shoulder; 2) Painful arc of movement during flexion in the sagital plane or abduction in the frontal plane; 3) Positive Neer's Test or Kennedy-Hawkins Test; 4) Pain on resisted external (lateral) rotation, abduction or Empty Can Test; 5) A combined DASH-CF (Disability of the Arm, Shoulder, and Hand - Canadian French) score (all 3 subsections) greater than 15%, or a WORC-CF (Western Ontario Rotator Cuff Index - Canadian French) score greater than 12%. The minimal scores for both the DASH and WORC questionnaires are based on their minimal clinically important difference (MCID) as reported by St-Pierre and colleagues in 2015.[194] Also, the combination of criteria 2), 3) and 4) have a good diagnostic accuracy with sensitivity and specificity values ≥ 0.74 and +LR = 3-5[158, 195] (Table 3).

TABLE 3

Special Test	Sensitivity (Sn) (CI 95%)	Specificity (Sp) (CI 95%)	LR+
1.Hawkins-Kennedy Test (n= 962)	0.83 (0.59-0.99)	0.69 (0.37-0.97)	2.68
2. Neer's Test (n= 966)	0.78 (0.52-0.98)	0.71 (0.35-1.00)	2.69
3. Painful Arch Sign (Between 60 – 120°) with shoulder flexion and/or abduction (n= 964)	0.62 (0.31-0.91)	0.82 (0.62-1.00)	4.33
4. Empty Can Test	0.74	0.67	1.81
5. Pain or weakness with external rotation	NE	NE	NE

N.B The Sp, Sn, LR+ (likelihood ratio), and CI (confidence intervals) values are based on a scientific systematic review on the diagnosis, management, and return to work guidelines for people affected by rotator cuff impairments, conducted by Roy and colleagues[23].

Table 3 Caption: Statistical properties of clinical diagnostic tests for RC tendinopathy.

Individuals with symptomatic shoulders were excluded if they verbally reported any prior history of shoulder surgery, dislocations, fractures, capsulitis, or demonstrate any systematic pathologies (such as diabetes, neurological signs or symptoms, complex regional pain syndrome, rheumatoid conditions, or signs and symptoms of vascular compression or vestibular dysfunction) The electronic records of each participant was subsequently checked for any relevant past medical history. Our sample size calculation was based on our primary outcome, the DASH questionnaire. Our calculation suggests 23 participants were required per group (G*Power 3.1.7; effect size: 0.846, $\alpha = 0.05$, $\beta = 0.80$, SD = 13 DASH points, clinically important difference (CID) = 11 DASH points, expected lost at follow-up =20%) (Figure 3).

FIGURE 3

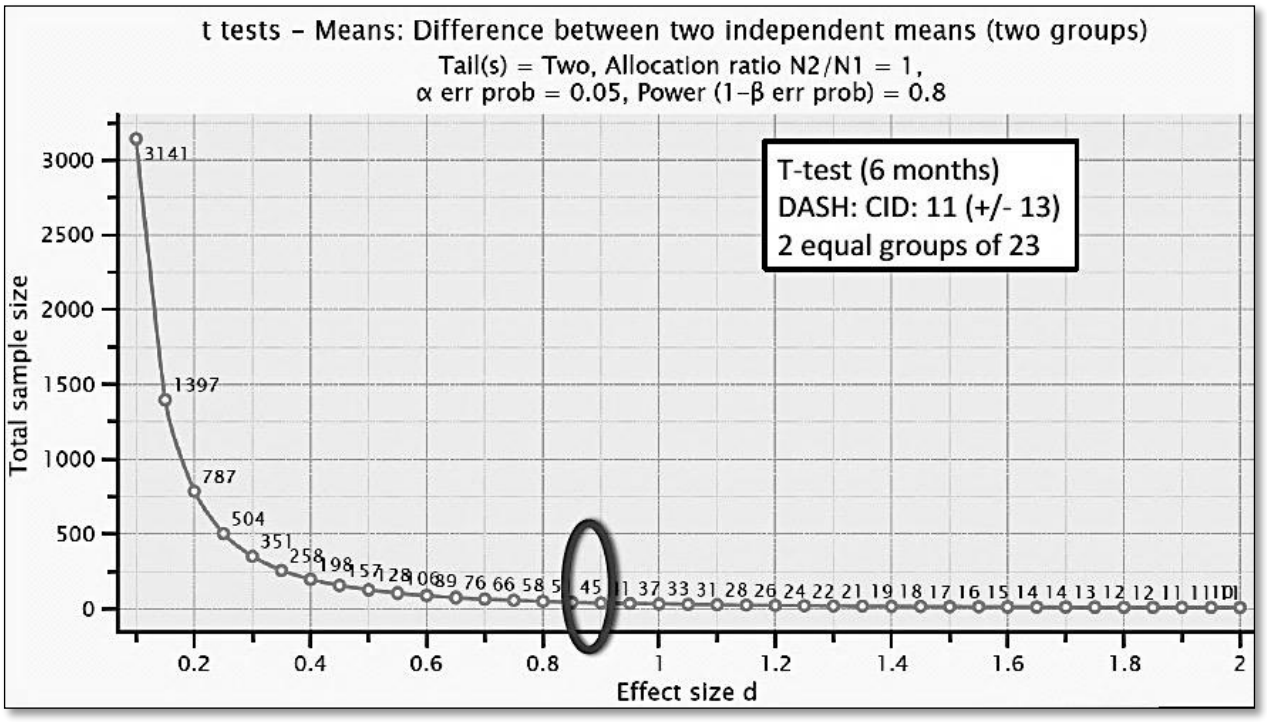


Figure 3 Caption: Effect size calculation for our pilot RCT

2.4 Instrumentation and outcome measures

All participants took part in a baseline evaluation session (T_0). The evaluators performed the evaluations according to standardized procedures and were all given a minimum of a 2-3 hour training session with each assessment tool used throughout this project. The clinical experience of the Physiotherapists who acted as the evaluators for this project, ranged from 5 years to over 20 years. All evaluators were

especially comfortable with shoulder evaluations and were able to perform the clinical special tests and work with the specialized equipment such as the hand-held dynamometer (HHD), with ease.

The outcome measures for this project included:

- The Disability of the Arm Shoulder and Hand (DASH) questionnaire[196, 197] (Primary Outcome);
- The Western Ontario Rotator Cuff (WORC) Index;[194]
- Reported pain via the 11-point verbal Numeric Pain Rating Scale (NPRS) (From 0 to 10);[198]
- Isometric strength for the external rotators and abductors of the shoulder;[199, 200]
- Global Rating of Change (GROC) scale;[201]
- Level of treatment satisfaction (via a Likert scale);
- Military specific task: 30 manipulations of sandbags in less than 3 minutes 30 seconds.[202]

TABLE 4

Dependent Variables	Outcome Measure
Shoulder Function	DASH Questionnaire • Reliability: ICC = 0.96 (95% CI, 0.93-0.98)[197] • Reliability Canadian French version: ICC = 0.93 [194] • Validity: r = > 0.70[197] • Clinically important difference (CID) = 11 DASH points[203, 204] WORC Index • MICD total score = 11.7% (moderate change)[205] • CID = 12-13% of total score[205] • SRM = 1.44[206] Canadian French version: 1.54[194] • Canadian French version: highly valid and reliable (ICC=0.96)[194]
Pain	Numeric Pain Rating Scale (NPRS) • French version: moderately reliable (ICC range 0.74-0.76)[207]
Strength	Hand Held Dynamometer (HHD) • Shoulder ER (inter/intra examiner ICC = 0.96/0.96)[199] • Shoulder ABD (inter/intra examiner ICC = 0.92/0.92)[199] • Good concurrent validity to a stationary isokinetic dynamometer (r=0.81)[200]
Perceived level of change	Global Rating of Change (GROC) questionnaire • Reliability: ICC=0.90, MCIC: 2 points[208, 209]
Military functional ability	Sand Bag Lift Task[202] • Standard (Pass / Fail): 30 consecutive lifts of a 20 kg sandbag from the floor above a height of 1.0 m.

	• To be completed in 3 minutes and 30 seconds.
Treatment satisfaction	11-point satisfaction likert scale (0 = very unsatisfied, 10 = very satisfied) • No known psychometric properties.

Clinically important difference (CID), Minimal detectable change (MDC), Minimally important clinical difference (MICD), external rotation (ER), abduction (ABD), intraclass correlation coefficient (ICC), standardized response mean (SRM).

Table 4 Caption: The psychometric properties of the special tests and outcome measures used for this study

2.4.1 Questionnaires

The level of symptoms and disability were assessed using two self-reported questionnaires, the Canadian French versions of the DASH questionnaire and the WORC Index. The DASH questionnaire, our primary outcome, assessed the entire upper limb symptoms and disability of the participants, while our secondary outcome, the WORC Index, a disease-specific quality of life questionnaire, evaluated the change in symptoms specific to their RC tendinopathy. At T_6 and T_{12}, participant's perceived level of change and self-reporting satisfaction were also evaluated using, the GROC (Global Rating of Change) scale and a 11-point Likert rating for satisfaction (0 not at all satisfied and 10 very satisfied with the provided treatment). The GROC scale uses a numerical score to reflect the perceived change of the participants' symptoms (1 = worse, 2 = stable, and 3 = better). If an improved (1) or worse (3) state was indicated, a numerical value of 1 - 7 was indicated by the participant, where 1 reflected "minimal improvement" and 7 indicated "great improvement".

2.4.2 Secondary outcome measures

Muscle impairments of each participant was assessed at T_0 and T_6 by evaluating their MVIC of their external rotators and abductors muscles, bilaterally, using a Medup® electronic hand-held dynamometer. The shoulder muscle strength evaluation was standardized and followed the protocols outlined in the Isometric Muscle Testing Manual by Hébert (2012)[210]. All evaluators participated in a standardized training session for all shoulder muscle groups tested. Physical limitations were assessed with the military sand-bag lift test, performed only T_6. Each participant was asked whether they felt capable of attempting the sand bag lift task, which includes lifting a 20 kg sand bag 30 times in the span of 3 minutes and 30

seconds.[202] If they provided verbal consent to perform the task based on their symptoms, and their reported shoulder pain was less than 3/10 at rest, the evaluator agreed to evaluate the military specific task. The number of sand bag lifts as well as the time to completion was recoded by the evaluator. Although this is not an established valid or reliable measure for shoulder function, it is a standardized military test, which is part of the Canadian Armed Forces physical fitness standard and is evaluated annually. This task was used as a clinical benchmark to assess the participants' level of military function and their ability to engage in their soldiering duties. Pain levels were assessed throughout the evaluations and interventions using the 11-point Numeric Pain Rating Scale (NPRS), where 0 represents "no pain" and 10 represents "worst pain imaginable". Participants were asked "*On a scale from 0 to 10, 0 being no pain at all and 10 being the worst pain imaginable, how would you rate your shoulder pain at this moment?".* A reduction of 2 points, or 30%, on the pain NPRS scores is said to be clinically important.[211] See Table 4 for associated psychometric properties of the assessed outcome measures.

Participants were subsequently contacted by telephone or e-mailed 12 weeks (T_{12}) after the initial evaluation in order to complete the DASH, WORC, GROC and satisfaction questionnaires to assess the effect of the interventions over time.

2.5 Randomization and blinding

A researcher not directly involved in the data collection generated a randomization list using a random number generator (block randomization) with stratification according to sex (male/female). Group allocations were concealed in sequentially numbered sealed opaque envelopes, which were opened by the scheduling administrative assistant of the military physiotherapy clinic at the Valcartier Garrison. Given the impossibility of blinding the participants to their treatment allocation, precautions were taken to ensure they were physically separated from the other treatment groups. Participants were instructed not to reveal the content of their program to the evaluator or to other participants. Three separate evaluators were involved is this project, evaluator 1 (ALA) from January 2015 – June 2016, evaluator 2 (MEP) from July 2016 – December 2016, and evaluator 3 (VC) from January 2017- June 2017. All three evaluators had at the time of the project a minimum of 5 years of clinical experience with evaluating shoulder pathologies. Each evaluator attended a familiarization and practice session (an estimated 3-5 hours) to become comfortable with all the equipment, special tests, and to standardize the physical examination. Each evaluator reported a high level of confidence with the subjective and objective

evaluations for this project. The treating physiotherapists (FG, PMV, MC, and SB) were also instructed to maintain absolute confidentiality of their patient list and treatments provided. All involved in this project understood that results of this study depended on full secrecy and blinding.

2.6 Interventions

Both interventions, the UpEx-NTP and the Usual Physiotherapy Care guidelines, were developed over a 2-year period (2015-2016) through a rigorous scientific literature review as well as based on clinical experience with military members. France Gamache, a Physiotherapist at the Valcartier physiotherapy department, was instrumental in the development of the UpEx-NTP. She was among the pioneers behind the development of a similar 6-week program for the lower extremity, referred to as the "*Proprioception Program*" and is considered to be the subject matter expert on shoulder pathologies at the military clinic. Similarly, a 6-week *Lumbar Stability Class* has been in place at the clinic for over 5 years and has experienced excellent clinical success in terms of patient participation as well as functionally significant gains for military members with non-specific low back pain. Through the success of both the *Proprioception Program* and the *Lumbar Stability Class*, it was noted that a group-exercise based approach works well with active military members. The foundation of this Master level project grew from the identification of a program gap for the upper extremity. Seeing as the shoulder is the fourth most common site for MSK injuries among military members,[24] it was only logical to develop a supervised group program to target this area of functional limitation. The following section will outline the support for the development of both interventions for our RCT.

2.6.1 The development of the Upper Extremity Neuromuscular Training Program

To comprehend the fundamental basis for the UpEx-NTP, it is imperative to return to the current biomechanical understanding of the physiological movements of the shoulder complex. It is well appreciated that the scapula provides the functional base for the shoulder complex during movements,[79, 119, 212] while also being a major attachment site for the stabilizing musculature of the shoulder and surrounding thoracic spine. A scapular dysfunction during arm elevation can therefore be a major hindrance of the ability of shoulder complex to perform coordinated movements of the upper limbs.[186] A scapular movement dysfunction has been well documented among individuals with a RC tendinopathy.[71, 115, 119, 143, 177, 213] For this reason, the development of our UpEx-NTP focused on motor (re)learning,

scapular and postural reeducation, as well as functional strengthening exercises. The program itself is comprised of 11 stations, which aims at presenting the participant with the neuromuscular ground-work to return to complex movements patterns necessary for everyday life, but with a strong sense of motor control of the upper extremity. Each station has a specific purpose and showcases various progressions of the same type of exercise to allow for a graduated and pain-controlled progression of neuromuscular loading. See Appendix M for a full visual depiction of the program as well as Appendix N for the tracking sheet used by the participants to record their progressions at every treatment session. The following is a brief introduction to each station included in the UpEx-NTP.

Station 1: Postural control

Goal: Train participants to adopt adequate GH positioning through proper biomechanical alignment and postural control of the thoracic cage and cervical spine.

Exercises: Maintaining a proper posture while sitting / standing, on stable / unstable surfaces, and finally throughout movement.

Evidence: STRONG

A biomechanically healthy shoulder starts with excellent postural control. Individuals with a forward head posture (FHP) can often experience shoulder pain,[214] because of the often associated anteriorization of the humeral head within the fossa that can accompany a FHP or thoracic kyphosis.

Station 2: Weight bearing

Goal: Encourage postural control during weight bearing movements as well as to stimulate the mechanoreceptors located within the GH joint while loading the joint.

Exercises: Progressive weight bearing against the wall, on an incline, full weight bearing, and finally on unstable surfaces.

Evidence: STRONG

To maintain a functional approach to rehabilitation, both open (non-weight bearing) and closed (weight bearing) kinetic exercises have been included in the program. Weight-bearing exercises results in joint approximation, ultimately stimulating the articular receptors.[215] The mechanoreceptors located within the joint capsule and surrounding soft tissue provide the joint with proprioceptive information that is vital to the dynamic stability of the joint throughout movement.[216]

Station 3: Neuromuscular (re)education of the rotator cuff muscles and in elevation (Station 4)

Goal: To introduce the shoulder complex to strength and motor control exercises, specifically designed to target the RC tendons.

Exercises: Movements of internal and external rotation as well as in elevation, particularly within the scapular plane (scaption). Begin with elastics, progress to free weights, through various joint angles.

Evidence: STRONG

The primary intervention for a rotator cuff tendinopathy is active exercise therapy,[104] as outlined by several systematic reviews on the subject[141, 146, 159, 217, 218] Our philosophy was based on a study by Suprak et al. (2005)[47] who promotes the use of unconstrained movements within functional ranges to increase muscle activation levels, to ultimately optimize motor control and proprioceptive feedback for both musculotendinous and mechanoreceptors located throughout the shoulder complex. This promotes a functional training approach and encourages dynamic motor (re)learning of the rotator cuff complex.

Station 5: Neuromuscular (re)education of the serratus anterior

Goal: Correction of altered scapular positioning / kinematics through the specific recruitment of the serratus anterior muscle.

Exercises: Awareness, recruitment and strengthening of the serratus anterior muscle. First with no resistance (controlled movements in elevation), followed by resistance training with therabands and free weights throughout movement.

Evidence: GOOD to STRONG

A suggestive cause for scapular dyskinesis is in alterations in muscle activation and control of the periscapular muscles, notably the serratus anterior and trapezius muscles. It is well documented that the dysfunctional SA muscle contributes to the loss of posterior tilting and the necessary upward rotation of the scapula during elevation.[153, 177, 187, 219, 220]

Station 6: Neuromuscular (re)education of middle / lower trapezius

Goal: Correction of altered scapular positioning / kinematics through the specific recruitment of the trapezius (middle/ lower) muscle.

Exercises: Awareness, recruitment and strengthening of the trapezius muscle. First with no resistance (controlled movements), followed by resistance training with therabands and resistant pulleys.

Evidence: GOOD to STRONG

Continues with the same scientific reasoning for Station 5. Research suggests that an imbalance between the activation of the upper trapezius (increased activity) and lower trapezius (reduced activity) contributes to scapular dyskinesis.[187, 219, 220] Several shoulder rehabilitation protocols focus on correcting the abnormal muscle activation of the trapezius muscle in order to optimize shoulder motor control.[220-222]

Station 7: Body Blade ®

Goal: Introduce external perturbations to the GH joint and shoulder complex to provoke reactionary stabilization through neuromuscular control. It is used to target small stabilization muscles, such as the rotator cuff complex.

Exercises: Vertical / horizontal perturbations with the Body Blade ®, first in static and then in dynamic conditions (movement, unstable surfaces).

Evidence: DEVELOPING

The use of the Body Blade ® is currently founded in Best Practices for shoulder rehabilitation, but is yet to be fully explored in the scientific literature. It is a portable and affordable piece of training equipment.

Station 8: Proprioception and motor control of the shoulder complex

Goal: To encourage participants to practice upper extremity functional movements within their surrounding space and environment in a pain-free and controlled manner.

Exercises: The manipulation of their limbs, objects, and free-weights throughout several degrees of freedom of their shoulder joints. Movements such as circles, figure-8s, and the alphabet are performed in a controlled and deliberate manner during arm elevation until fatigue.

Evidence: STRONG

Motor control and proprioception exercises are essential to shoulder rehabilitation.[84, 97, 98, 189] Revisit Chapter 1 for a full explanation of the importance of motor control and proprioception exercises for the health and homeostasis of the shoulder complex.

Station 9: Throwing

Goal: To practice throwing movements with a proper motor control throughout movement and without the solicitation of pain.

Exercises: Throwing is practiced throughout various joint angles, with balls of difference sizes and weights, at different speeds, as well as on / with different surfaces (against the wall, targets, trampolines, and bosu balls).

Evidence: STRONG

Among the most functional movements of the upper extremity is throwing.[62, 223] Being able to recruit the appropriate agonist and antagonist musculature in order to execute a precise task such as throwing (particularly over-head throwing), involves a high-level of neural-cortical ascending and descending feedback for the entire upper limb. Throwing also proves to be a symptom-provoking task for many individuals affected by SIS or a RC tendinopathy.[187, 223]

Station 10: Functional activities

Goal: Introduce functional activities for high-end athletes and soldiers. Provide an environment to practice the activities progressively and without pain.

Exercises: Pushups, bench press, and progressive sand bag lifts.

Evidence: DEVELOPING
Although every clinician will tell you functional activities are essential to rehabilitation, the type, frequency, and progressions of such activities have yet to be clearly defined within the scientific literature. Station 10 was developed through clinical experience and common military activities that are often reported as symptom provoking for individuals with a RC tendinopathy.

Station 11: UQYBT

Goal: To practice the Upper Quadrant Y-Balance Test (UQYBT) of the Selective Functional Movement Assessment (SFMA) evaluation method. The SFMA is a tool specifically designed to evaluate trunk rotation, core stability, and upper extremity function and performance.[224]

Exercises: In a weight-bearing position, push a mobile plastic box as far as possible in three directions, bilaterally.

Evidence: DEVELOPING
This is a relatively new tool on the clinical market and is still developing for use with the upper extremities. A study by Westrick and colleagues (2012),[224] suggest that the tool has excellent (ICC>0.9, $p<0.05$) test-retest reliability and can be confidently used to assess unilateral upper extremity function in a CKC task. Despite the UQYBT being in its scientific infancy, it is gaining traction in a clinical setting for rehabilitation purposes with high-end athletes.

2.6.2 UpEx-NTP parameters

The UpEx-NTP program consists of 35-45 minutes of exercise, three times a week for 6 weeks (18 treatments, for an estimated 9-10 hours), supervised by a trained physiotherapist (FG). The participant chooses one exercise to perform per station based on their current ability while respecting their pain levels at 3/10 or less. It is possible the participant will not complete all 11 stations within the 35-45 minutes. As long as the participant is continuously challenging themselves they are following the intention of the program. The participant was to maintain their pain at 3/10 or less, be continuously moving throughout the program, and should demonstrate a fatigue performing the last few recommended repetitions of each station. The stations were organized by level of difficulty, meaning the first station is less physically challenging than station 11. There was no directive to finish all 11 stations at each treatment session. The goal of the program was to be able to attempt the more difficult stations by week 5 or 6 of the program. The program allows for the individualized progressions of each station, under the guidance of the physiotherapist. Furthermore, the supervising physiotherapist (FG) can challenge the

participant by encouraging more difficult exercises as long as their pain is managed at 3/10 or less throughout the entire program. If the exercise appears to be too difficult (difficulty with movement control) or causing too much discomfort, the supervising physiotherapist may suggest a less stressful version of the exercise (as outlined by each station). Their progressions, exercises, and parameters will be documented on their progress tracking sheet at every visit. All exercises are also encouraged to be performed on the non-affected side.

2.6.3 The development of the Usual Physiotherapy Care (UPC) guidelines

The UPC guidelines were developed in full cooperation with the Physiotherapists from the physiotherapy department at the Valcartier Garrison. The researchers responsible for the project (ALA, LJH, JSR) organized a round-table discussion to document what is currently being practiced within the clinic for military members presenting with a RC tendinopathy. In order to remove any chance of bias, France Gamache, PT was not present for the discussion as she was a contributing member to the conception of the motor control program and was the supervising Physiotherapist for the UpEx-NTP. Eleven Physiotherapists and 3 Researchers were present for the meeting that took place to standardize the UPC and ensure a common understanding and rational for it. The clinical experience ranged from 2 years to over 22 years and every Physiotherapist present consented to providing their feedback for the development of the guidelines. From the discussion, clear guidelines were developed for the usual physiotherapy care practice for this project. See Chapter 4 (Methodology section) for the guidelines, as well as Supplementary Appendix L for the treatment form employed.

Space was provided on the treatment tracking sheet for the Physiotherapists to be very clear as to the nature of the prescribed exercises, in order to document the position, material used, tissue targeted, as well as the parameters (repetitions, rest, series) of the treatments provided. Specific exercises were not included on the tracking sheets to avoid any sort of encouragement or bias for the selection of strengthening or motor control exercises. Exercise prescription was completely subjected to the prerogative of the treating physiotherapist.

2.6.4 The usual physiotherapy care (UPC) protocol and parameters

The control group received UPC treatments during a 6-week period. Participants in the Ctl group received an initial evaluation (60 minutes), followed by 2 physiotherapy treatments (30 minutes) in the clinic per week (total of 12 treatments) as well as an individualized home exercise program (HEP) as determined by the treating physiotherapist, to be performed 2-3 times a week (6 hours of one-on-one physiotherapy care and an estimated 3-4 hours of home exercises for a total of 9-10 hours of treatment). The treating physiotherapists (SB, PMV, VC, MC) will not have any knowledge of the UpEx-NTP during this RCT. See Appendix L for a copy of the usual physiotherapy care tracking sheet.

2.7 Statistical analysis

Descriptive statistics were used for all outcome measures at each measurement of time to summarize results. Baseline demographics were compared (Independent t-test and chi-square tests) to establish the comparability of groups. All data was tested to check the distributional assumptions for the inferential statistical analyses. An intention-to-treat (ITT) and per-protocol analysis (PPA) were performed for the DASH-CF questionnaire (all sub-categories, General, Sports, and Work), the WORC-CF Index (Total score only), pain levels at rest, and the measurements of strength for both shoulders. The effects of the interventions on the DASH-CF and the WORC-CF were analyzed using a 2 × 3 (Exp + Ctl groups × T_0, T_6, and T_{12}) repeated measure analysis of variance (ANOVAs). Similarly, a 2 × 2 × 2 (group × time × shoulder) repeated measure ANOVAs was used for MVIC and a 2 × 2 (group × time) ANOVA was used for pain to compare values from T_0 and T_6 for both groups. Descriptive statistics and a chi-squared test were used to analyze the results from the GROC questionnaire, while an independent t-test was used for the comparability of groups for the sandbag lift. Descriptive statistics were reported (median ± standard deviation) as well as the associated confidence intervals (95%CI) for each group. Furthermore, a chi-square test was used to evaluate the difference between compliance levels for each group. The number of sessions attended were counted and then normalized to 100% for each group. A fair compliance rate has been established to reflect a participant attending 50-74% of their treatment sessions, good compliance as 75-89% attendance, and excellent compliance as 90-100% attendance of their treatment sessions. All analysis was performed using SPSS version 24.0 (SPSS, Chicago, Ill) for Mac software, with all α values set to 0.05.

2.8 Feasibility, potential risks, and ethics

2.8.1. Feasibility

As a former military physiotherapy employed at the Valcartier Garrison for 5 years, I (ALA), have a thorough understanding of the military context and as principal evaluator for the project, I am highly visible to medical staff at the military hospital. Clinical statistics reported at the Valcartier physiotherapy clinic from 2015 estimate 15-20 shoulder cases seen for treatment per month. The clinical statistics also suggest that RC disorders are the most clinically prevalent shoulder pathology in the military.

2.8.2 Potential patient risks

Participants from both the Exp and Ctl groups were briefed on the possibility of delayed onset muscle soreness (DOMS); which can be expected after an exercise session, their home exercise program (HEP), and potentially their physiotherapy treatments. Overall, participants will not be denied the necessary care for their condition; treatments will be documented throughout the interventions as needed. All evaluations and treatments took place at the military hospital and the physician on-call was always readily available. No financial compensations was provided for this project seeing as military regulations prohibits financial compensation for research participation.

2.8.3 Ethics

Scientific approval for this project has been granted by the CRIR / CIRRIS (CIRRIS-15-0715) as well as the ethical approval was granted by IRDPQ ethics committee (Project # 2015-446) and January 2016. The Canadian Armed Forces Surgeon General Health Research Program (SGHRP) also provided it's ethical approval.

2.9 Funding

Funding for this project included a student bursary from the CIRRIS / IRDPQ and Laval University (awarded to ALA) as well as a research grant from the REPAR / OPPQ 4.2 research program for clinical projects.

CHAPTER 3

SHOULDER PROPRIOCEPTION: HOW IS IT MEASURED AND IS IT RELIABLE? A SYSTEMATIC REVIEW

Amanda L. Ager[1,2], Jean-Sébastien Roy[1,2], Marianne Roos[1,2], Amélie Fournier Belley[1,2], Ann Cools[3], Luc J. Hébert[1,2]

1. Center for Interdisciplinary Research in Rehabilitation and Social Integration, Rehabilitation Institute, Quebec City, Quebec, Canada;

2. Departments of Rehabilitation and Radiology/Nuclear Medicine, Faculty of Medicine, Laval University, Quebec, Canada

3. Department of Rehabilitation Sciences and Physiotherapy, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium

Primary contact:

Ager, Amanda MSc(c) Exp Med, MSc PT, BKin, Laval University; Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Quebec.

Address: CIRRIS-IRDPQ, 525, boulevard Wilfrid-Hamel, Quebec (QC) G1M 2S8, Canada

Telephone: 1-418-529-9141 ext. 6005, or +40 748 961 302

Email: amanda.ager.1@ulaval.ca

Secondary contact:

Hébert, Luc J. PT, PhD Laval University; Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Quebec.

Address: CIRRIS-IRDPQ, 525, boulevard Wilfrid-Hamel, Quebec (QC) G1M 2S8, Canada

Telephone: 1-418-529-9141 ext. 6579

Fax: 1-418-529-3548

Email: lucj.hebert@fmed.ulaval.ca; ljhebert@videotron.ca

This article has been published in the *Journal of Hand Therapy* Apr - Jun;30(2):221-231.

doi: 10.1016/j.jht.2017.05.003.

3.1 Problem Statement

Shoulder proprioception has become increasingly recognized as essential to our neuromuscular homeostasis. It is a key player in the normalized function of our joints and surrounding neuromuscular tissues, notably for our glenohumeral joints. Despite being recognized as important, the physiological construct of proprioception has yet to be confidently quantified. Current methods of measuring shoulder proprioception involve complex custom-built laboratory equipment that are not readily accessible in a clinical setting. The purpose of this systematic review was to collect and synthesize the current research that measures proprioception at the shoulder complex. To be more precise, to evaluate the psychometric properties associated with a tool or protocol that attempts to quantify either joint position sense, or kinesthesia, both of which are subcategories of proprioception.

3.1.1 What is already known on this topic

Proprioception has often been described as our sixth sense, which includes our ability to determine where our limbs are in space (joint position sense, JPS) and our ability to detect movement (kinesthesia). It is well established that our proprioceptive sense is intimately linked to our ability to interact with our environment without sustaining injury, and is therefore increasingly of interest in rehabilitation fields, particularly at the shoulder joint. The glenohumeral (GH) joint is inherently unstable and relies heavily on neuromuscular control and proprioceptive acuity to maintain stability and ensure controlled movements. Assessment of proprioception is foundational to the identification of impairments and managing them in individual patients. A synthesis of current research addressing outcome measures can be used to establish optimal measurement approaches. The purpose of this systematic review is to identify studies which present the measurement properties of shoulder proprioception, specifically JPS and kinesthesia, and to synthesize the data of the presented psychometric properties (validity, reliability or responsiveness).

3.1.2 What our study adds

This study provides a comprehensive literature review addressing shoulder proprioception protocols and their psychometric properties. This review includes 21 studies and presents the calculations of weighted averages for intra-class correlation coefficients (ICCs) of intra-session and inter-session reliability

measures for shoulder proprioception protocols. This review makes preliminary recommendations on the most reliable direction of movement, method of proprioception assessment and type of equipment used during protocols. Lastly, the authors are demonstrating the overall lack of standardization for measuring shoulder proprioception, in the hope of encouraging future research on the validity, reliability, and responsiveness of protocols.

RÉSUMÉ

Introduction : Les composantes de la proprioception incluent le sens de la position (sens de la position articulaire (SPA)) et du mouvement (kinesthésie) de nos membres dans l'espace. Les déficits proprioceptifs associés à des pathologies musculosquelettiques représentent un défi à quantifier et ce particulièrement à l'épaule. Objectif : Déterminer les qualités métrologiques de validité, fidélité et sensibilité au changement pour des protocoles de mesures du SPA et de kinesthésie à l'épaule. Méthodes : Une revue de cinq bases de données a été conduite de octobre 2015 à juillet 2016 pour des études rapportant des données sur les propriétés métrologiques de protocoles d'évaluation de la proprioception à l'épaule. Les études incluses ont été évaluées à l'aide de l'outil de contrôle QualSyst et de l'échelle COSMIN à 4 points. Résultats : Vingt et une études incluant 407 participants et 553 épaules évaluées (n) ont été retenues. Les études analysées confirment d'excellents scores méthodologiques avec l'outil QualSyst (88,1 ± 9,9%) et de bons scores avec le COSMIN pour la fidélité (71,1%) et un score de qualité modérée à faible (50%) pour la validité de critère. Les coefficients de corrélation intraclasse (CCI) pondérés pour la fidélité intraévaluateur étaient les plus élevés pour les SPA passifs et la kinesthésie soit 0,92 ± 0,07 (n = 214) et 0,92 ± 0,04 (n = 74), respectivement. Le mouvement et l'outil les plus fidèles sont la rotation interne à 90 ° d'abduction (CCI = 0,88 ± 0,01 (n = 53)) et le dynamomètre (CCI = 0,92 ± 0,88 (n = 225)). Seules deux études ont quantifié un aspect de la validité et aucune étude n'a rapporté d'indices de sensibilité au changement. Conclusion : Selon les résultats des études retenues, l'évaluation de la proprioception de l'épaule serait plus fidèle avec l'utilisation d'un protocole passif avec dynamomètre isocinétique en rotation interne à 90° d'abduction de l'épaule. Des protocoles standardisés traitant des propriétés métrologiques des mesures de proprioception à l'épaule sont nécessaires.

ABSTRACT

Introduction: Constituents of proprioception include our awareness of the position (joint position sense, JPS) and motion (kinesthesia) of our limbs in space. Proprioceptive deficits are associated with musculoskeletal disorders, but remain a challenge to quantify, particularly at the shoulder. Purpose: To report the psychometric values of validity, reliability and responsiveness for shoulder JPS and/or kinesthesia protocols. Methods: A review of five databases was conducted from inception to July 2016 for studies reporting a psychometric property of a shoulder proprioception protocol. Included studies were evaluated using the QualSyst checklist and the COSMIN 4-point scale. Results: Twenty-one studies were included, yielding 407 participants and 553 evaluated shoulders (n). The included studies support excellent methodological scores using the QualSyst checklist (88.1 ± 9.9%), and good psychometric scores with the COSMIN for reliability (71.1%) and moderate-to-low quality score (50%) for criterion validity. Weighted average intraclass correlation coefficients (ICCs) for intra-rater reliability were highest for passive JPS and kinesthesia, ICC=0.92 ± 0.07 (n=214) and ICC=0.92 ± 0.04 (n=74), respectively. The most reliable movement and tool are internal rotation at 90° of abduction, ICC=0.88 ± 0.01 (n=53), and the dynamometer, ICC=0.92 ± 0.88 (n=225). Only two studies quantify an aspect of validity and no responsiveness indices were reported among the included studies Conclusion: Based on the results of the included studies, the evaluation of shoulder proprioception is most reliable when using a passive protocol with an isokinetic dynamometer for internal rotation at 90° of shoulder abduction. Standardized protocols addressing the psychometric properties of shoulder proprioception measures are needed.

Key words: shoulder, proprioception, joint position sense, kinesthesia, reliability, psychometric properties, systematic review

3.3 Introduction

Proprioception is not a new concept, first introduced as our "*muscular sense*" by Charles Bell in 1826 and later elaborated by Charles Sherrington, who coined the term "*proprioception*" in 1906, as: *our perception of joint movement and positioning in space in the absence of visual feedback.* [3] Proprioception has evolved over time to become an overarching theme, including the sub-categories of *kinesthesia*, the awareness of passive or active joint movement, *joint position sense*, the reproduction of joint angles actively or passively, [225, 226] as well as our ability to detect *vibrations*, [5] level of *force production*, [227] and changes in limb or joint *velocity*. [228]

The role of proprioception is well depicted in the context of the shoulder joint. Due to its vast mobility, it is inherently an unstable joint,[229] relying heavily on the synchronicity of its active and passive structures for dynamic neuromuscular control.[2, 230] The active and passive tissues contribute to proprioceptive awareness through the input provided by mechanoreceptors (Figure 10) located within the structures of the shoulder complex.[226, 231-233] Proprioception is thus the sum of neurological feedback from multifaceted systems that regulate motor control and behaviour[231, 232, 234] and is widely recognized as being important for motor control rehabilitation and overall physical health.[6, 235]

Considering its importance in healthy movement production, one may wonder if there is an association between poor proprioception and musculoskeletal (MSK) disorders. Indeed, it has been demonstrated that proprioceptive deficits are related not only to MSK injury but also to the recurrence and persistence of symptoms and disability.[91, 95, 96] This relationship suggests, firstly, that rehabilitation programs should aim to improve neuromuscular control and proprioceptive capacities and secondly, that proprioception should be objectively measured throughout rehabilitation. Although an increasing number of studies exploring the effects of proprioceptive rehabilitation has indicated the effectiveness of this type of intervention in the treatment of MSK disorders such as ankle instability, anterior cruciate ligament reconstruction, and osteoarthritis,[217, 236] other results have been less promising and indicate a need for further study.[217, 231, 237] The difficulty of evaluating the effects of proprioceptive rehabilitation is that the measurement of proprioception itself remains a challenge.[238, 239] As proprioception has been linked to the persistence of impairments and physical limitations,[91, 95, 96] it would be advantageous to measure it objectively in a clinical setting.

The psychometric properties of protocols are important to understand in order to objectively quantify an individual's level of impairment, physical limitations, and/or restrictions of participation. Such qualities include strong validity, reliability, and responsiveness measures to establish the credibility and usefulness of a measure for quantifying neuromuscular function.[240-243]

The purpose of this systematic literature review is to identify and report the psychometric values of validity, reliability and responsiveness from studies quantifying shoulder proprioception in adults, measured as JPS or kinesthesia. Presentation of this systematic review follows the recommendations outlined by PRISMA. [244]

3.4 Methodology

3.4.1 Literature search and study identification

A literature search was conducted by two reviewers (ALA and MR) using five databases including PubMed (Ovid MEDLINE), EMBASE, CINAHL, PEDrO, SPORTDiscuss, the reference system EBSCO, as well as a manual search of references from all retrieved articles. The search was performed from inception to July 15th 2016 and included the key terms proprioception (proprio*), kinesthesia (kinesthes*), joint position sense, clinical tool*, clinical measure*, outcome measure*, validity, reliability, responsiveness, sensitivity, specificity and diagnostic accuracy. Combined controlled vocabulary specific to each database was used (for example: Medical Subject Headings (MeSH) for Medline and Emtree for the EMBASE). The search strategy was developed with the guidance from a technician in documentation.

3.4.2 Study Selection

Two evaluators (ALA and MR) independently reviewed the titles and abstracts of each article for screening eligibility. Subsequently, the two raters reviewed each article, addressed the inclusion criteria, and came to a consensus for inclusion. An article was accepted for a full review if it met the following inclusion criteria: 1) reported on at least one psychometric property addressing either joint position sense (JPS) or kinesthesia of the shoulder (laboratory or clinical measure), 2) written in French or English, and 3) included adult participants with or without an MSK disorder of the shoulder. An article was excluded if it referenced the psychometric properties of a previous study and if it evaluated the sense of vibration,

detection of joint or limb velocities, or perceived levels of force production. Articles evaluating either JPS or kinesthesia were selected because they are the most employed methods for quantifying shoulder proprioception.[245]

3.4.3 Data extraction and shoulder proprioception measurements

Information was extracted by one evaluator (ALA) systematically using a standardized form, which included the population, type of proprioception investigated, evaluation methods and equipment, direction of shoulder movements, and reported psychometric values of the protocols. The information was then verified by two other evaluators (MR and AFB).

JPS and kinesthesia measures were the main outcome for this review, which included active joint position sense (AJPS): actively moving the limb to a target angle; active path of joint motion replication (PJMR): the reproduction of a specific angular trajectory; threshold to detection of passive motion (TTDPM): the detection of motion externally initiated at the joint; and reproduction of passive positioning (RPP): where the limb is moved passively by the evaluator or a device.[95] Ipsilateral and contralateral matching tasks were included.

3.4.4 Quality Assessment

Three evaluators (ALA, MR, AFB) independently assessed all included articles with two checklists: the Standard Quality Assessment Criteria for Evaluating Primary Research Papers (QualSyst) [246] and the COSMIN 4-point scale [247, 248] for psychometric assessment. The raters then met to openly discuss each article and to reach a consensus. This process allowed us to address any disagreements in the interpretation of the data or the scoring process. When no consensus was reached, the evaluators applied the default option of the lowest awarded score. If any rater was uncomfortable with this resolution, a fourth rater (JSR) reviewed and scored the article. A pre-consensus inter-rater absolute agreement was calculated using an intraclass correlation coefficient (ICC) in order to evaluate the level of agreement between the evaluators.

3.4.4.1 Standard Quality Assessment Criteria for Evaluating Primary Research Papers

The QualSyst is a quality appraisal tool developed by Kmet and colleagues (2004) that evaluates the methodological quality and risk of bias of quantitative and qualitative studies with varying study designs.[246] It is comprised of 14 items, however for the purpose of this review, items 5 (random allocation), 6 (blinding of investigators) and 7 (blinding of subjects) were removed from the scoring because the included studies were mainly methodological. Item 9 (sample size) was also excluded because it was assessed using the COSMIN 4-point scale. Each item was assessed using a 3-point scale (0-2), for a total score of 20 points, which was then normalized to 100%. Since there is currently no classification threshold associated with the scale, we categorized each article based on its awarded percentage, $\geq$ 75% being an excellent quality study, 51-74% representing a good study, and $\leq$ 50% suggesting a moderate-to-low quality study.

3.4.4.2 COSMIN 4-point scale

The COSMIN 4-point scale is a checklist developed by Terwee and colleagues (2012) and is recommended for use in systematic reviews of measurement properties such as validity, reliability and responsiveness.[247, 248] Each box of the COSMIN tool represents a different psychometric property. Only the evaluation boxes that specifically address the psychometric property of the included studies were utilized. Box B of the COSMIN 4-point scale was used to evaluate reliability and Box H was employed to assess criterion validity. Because the COSMIN 4-point scale uses qualitative descriptions for scoring, the scoring system was converted in order to obtain a quantitative score (excellent = 4, good = 3, fair = 2 and poor =1). Box B for reliability has a maximum potential score of 44 points, seeing as items 12, 13 and 14 were excluded (representing dichotomous, nominal, or ordinal scores). Box H for criterion validity has 7 items and using the same quantitative scoring technique of 1 to 4, has a total score of 28 points. As with the QualSyst checklist, the total was normalized to 100% and categorized for quality assessment.

3.4.5 Data analysis

Weighted averages (WA) of ICC measures for both intra-session and inter-session reliability were calculated and weighed according to the number of shoulders evaluated (n). WAs were calculated for the

type of proprioception measured, the direction of shoulder movement, and the type of equipment used during the protocol. Studies that reported inter-rater reliability or a correlational value were not included in the WA calculations. Studies included could not be pooled into a meta-analysis due to the variability between proprioception protocols performed in each study.

3.5 Results

3.5.1 Description of the studies

The literature search resulted in 262 articles, from which 167 duplicates were removed and the remaining 95 articles had their titles, abstracts, and results screened for eligibility. Seventy-four articles were excluded; therefore 21 articles were included and the full texts were assessed (Figure 5). A total of 407 participants and 553 shoulders (n=553) were evaluated for the psychometric properties of the shoulder proprioception protocols.

3.5.2 Quality of the included studies

Scores from the QualSyst checklist ranged from 12/20 (60%)[249] to 20/20 (100%),[53, 99, 250] with a mean score of 88.1 ± 9.9%. The COSMIN 4-point scale checklist Box B scores ranged from 27/44 (61.3%) [233, 251] to 39/44 (88.6%), [99] with a mean score of 71.1 ± 8.0%. Two studies[63, 252] were evaluated using COSMIN Box H for criterion validity, and earned identical scores of 14/28 (50%). Pre-consensus inter-rater agreement on the total scores were good for the QualSyst scale (ICC = 0.71 (95% CI: 0.63-0.77)) and excellent for the COSMIN 4-point scale Box B (ICC =0.90 (95% CI: 0.88-0.92)) and Box H (ICC=0.99 (95% CI: 0.97-0.99)).

3.5.3 Specific findings

3.5.3.1 Population

Different populations were investigated among the included studies: 14/21 (66.7%)[47, 63, 91, 225, 233, 249-257] used healthy participants (n=435), five (23.8%) used healthy athletic populations (n=74)[53, 258-261] and lastly, two studies (9.5%) tested individuals with pathological shoulders (n=44), which included participants affected by chronic rotator cuff pathologies (CRCP)[99] and multidirectional instability (MDI) of the shoulder.[262]

3.5.3.2 Type of proprioception evaluated (Figure 6)

The proprioception measures of our review address either JPS, which includes AJPS, PJPS, RPP, and PJMR tasks, or kinesthesia, which includes TTDPM tasks. AJPS was evaluated in 16 studies [47, 53, 63, 99, 225, 233, 249, 250, 252-258, 261] (n=479). Among the AJPS studies, variability existed as to whether the movement was actively or passively demonstrated and then actively executed, respectively. Five studies promoted an active/active protocol [47, 63, 225, 250, 255] (n=112), one study an active-assisted protocol [255] (n=10), and twelve studies performed a passive/active protocol [53, 99, 233, 249, 252-258, 261] (n=337). Eight studies[91, 233, 249, 251, 255, 257, 259, 262] examined passive joint position sense (PJPS or RPP) (n= 454). Two studies[233, 255] evaluated PJMR (n=10), and 6 studies evaluated TTDPM (kinesthesia)[91, 233, 251, 259, 260, 262] (n=114). Interestingly, nearly all proprioception protocols used an ipsilateral task (95.2%), with the exception of Ramsay and Riddoch (2001) who employed a contralateral matching task.[256]

The intra-session WA ICCs indicate that PJPS has the strongest reliability (0.92 ± 0.07, n=214), followed by passive/active protocols (WA ICC of 0.92 ± 0.1, n=204), and TTDPM (0.92 ± 0.04, n=74), respectively. The active/active protocol revealed the lowest intra-session WA ICC (0.34 ± 0, n=22). Inter-session calculations reveal a similar pattern with TTDPM demonstrating the strongest reliability (0.92 ± 0, n=10) followed by AJPS protocols (0.87 ± 0.14, n=314).

3.5.3.3 Direction of movement (Figure 7)

The included studies used various movements of the shoulder complex to quantify proprioception, including flexion[47, 63, 233, 250, 256, 258] (n=112), internal rotation (IR) at 90° of abduction (ABD)[91, 225, 233, 249, 258, 260] (n=154), external rotation (ER) at 90° of ABD[53, 91, 225, 233, 249, 251, 257-262] (n=389), scaption[47, 99, 254] (n=66), scapular movements (elevation, depression, retraction, and protraction)[252] (n=20), horizontal adduction (ADD) and ABD[255] (n=10), pure ABD[256] (n=8), and combined movements (F/ABD/ER through E/ADD/IR)[253] (n=11).

IR and ER protocols support the strongest WA ICCs for both intra and inter-session reliability. IR leads with an ICC of 0.88 $\pm$ 0.01 (n=53) (intra-session) and 0.98 $\pm$ 0 (n=31) (inter-session), closely followed by ER WA ICC=0.83$\pm$0.04 (n=303) (intra-session), WA ICC=0.97 $\pm$ 0.04 (n=41) (inter-session). Scaption is the least reliable direction of movement with an intra-session WA ICC of 0.34 $\pm$ 0 (n=33).

3.5.3.4 Equipment (Figure 8)

The isokinetic dynamometer was used the most frequently for both JPS[233, 249, 251, 253, 257] and kinesthesia[233, 251] (n=225). Other proprioceptive equipment included an inclinometer[63, 225] (n=56), a laser pointer[63] (n=25), a goniometer[63] (n=25), a continuous passive motion device (CPM)[259] (n=10), fabricated laboratory equipment[252, 255, 260] (n=50), a purpose built active movement extent discrimination assessment (AMEDA) tool[250] (n=24) and a motion analysis system[47, 63, 99, 258] (n=100). Furthermore, three studies conducted a photograph analysis with a goniometer[53, 256, 261] (n=19), one study used an Apple 4th generation iPod touch using internal sensors of the device (accelerometers and gyroscopes)[254] to evaluate AJPS (n=24) and lastly, two studies[91, 233] used a proprioceptive testing device (n=30).

WA ICC calculations demonstrate that the isokinetic dynamometer is the most reliable tool for measuring shoulder proprioception (intra-session: 0.92 $\pm$ 0.08, n=225), succeeded by the CPM device (inter-session 0.91, n=10). The least reliable equipment includes the goniometer (inter-session 0.6 $\pm$ 0, n=25), the motion analysis system (intra-session 0.66 $\pm$ 0.27, n=55) and fabricated lab equipment (inter-session 0.69 $\pm$ 0.12, n=30).

3.5.3.5 Validity, reliability, and responsiveness

All 21 included studies reported a measure of reliability, which included intra-rater ICCs (21/21, 100%), inter-rater ICCs (3/21, 14.28%),[63, 249, 256] standard error of measurement (SEM) (8/21, 38%),[47, 63, 99, 251-253, 255, 259] minimal detectable change (MDC) (2/21, 9.5%)[63, 252] (Table 5), intra-tester reliability as a correlation between measurements (2/21, 9.5%),[91, 261] or a Cronbach alpha value (1/21, 4.76%).[256] Only two studies (9.5%)[63, 252] presented validity values, expressed as a Pearson product-moment correlation coefficient (r), with 95% of agreement as an estimate for criterion validity. Vafadar et al. (2015) compared their protocol to the Vicon motion capture system and found all three of their instruments to have a high correlation to the Vicon: the laser pointer (r=0.85), the inclinometer (r=0.80) and the goniometer (r=0.77). Deng and Shih[252] evaluated the validity of their scapular repositioning error by using a 3D electromagnetic tracking device and a scale ruler (r=0.74-0.98). None of the included studies presented any measures of responsiveness.

3.6 Discussion

Proprioceptive acumen is essential for the optimization of shoulder neuromuscular control throughout movement, yet continues to be a quantitative challenge today. Due to the lack of standardization of proprioception terminology and the complexity of evaluation methods, it remains an area of psychometric contention. The purpose of this systematic review was to identify and summarize the current methods used for quantifying shoulder proprioception, specifically JPS and kinesthesia. Although shoulder proprioception impairment is deemed extremely important to evaluate and treat during rehabilitation, the protocols currently being used have not been thoroughly psychometrically tested. A proprioceptive outcome that is being employed in a clinic without known psychometric qualities can lead to erroneous clinical decisions and provide a false impression that an evidence-based approach is being used.

Our WA values reveal that passive protocols demonstrate greater reliability and that protocols employing IR or ER at 90° of shoulder ABD are the most reliable over time. The isokinetic dynamometer supports the highest reliability measures and is the most employed piece of equipment for the evaluation of shoulder proprioception, both for active and passive protocols. Furthermore, our results echo those of

previous shoulder proprioceptive studies, that there is currently no universally accepted method for quantifying a proprioceptive impairment of the shoulder.[6, 95, 235]

Similarly to our results, Hillier et al.'s (2015) systematic review on proprioceptive measurements in the lower back, ankle, knee and shoulder found few protocols that reported their psychometric properties,[239] putting into question the robustness, and utility of such proprioceptive protocols in a clinical setting.[239] Indeed, this has been mirrored by other reviews addressing proprioceptive deficits of the lower back,[94] knee[263, 264] and ankle[265] which reported moderate to good psychometric properties at best. Moreover, these articles point out the small sample sizes of proprioceptive studies, suggesting overall weak statistical power and thus offering no clear guidelines for clinicians. Although Han and colleagues[6] more recently performed a thorough literature review of proprioceptive evaluation methods for the ankle, knee and shoulder, they did not report any associated psychometric properties. Our review reports the psychometric values of shoulder proprioceptive protocols, thereby contributing to a more comprehensive and complete review of the current literature. This review provides clinicians with the confidence to use an outcome measure or protocol that is based on scientific support. Han and colleagues[6] did, however, outline the importance of a proprioceptive outcome demonstrating strong ecological validity,[6] so that it may in turn be used in a clinical environment.

3.6.1 Ecological validity and the clinical application of proprioception

In addition to strong psychometric properties, a proprioceptive outcome must support a secure sense of ecological validity, which can be understood as "maintaining the integrity of the real-life situation in the experimental context while remaining faithful to the larger social and cultural context".[266, 267] When evaluating proprioception, it is important that the procedures maximize the similarities between the testing setting and real-life functionality.[266] From our review, kinesthesia measures demonstrated stronger reliability. This can be attributed to the fact that movement threshold testing relies solely on passive movements and structures,[268, 269] arguably better representing our afferent sensory feedback processing or proprioceptive sense.[235] However, functional daily activities are performed predominantly with the use of our active muscular system,[249, 270, 271] which is not activated during TTDPM except when stretched to end range. It can be said that active position matching tasks are a stronger indicator of joint function than passive protocols.[47, 255, 272, 273] As such, although the TTDPM has a higher conceptual purity

of proprioception,[6, 235] it conceivably has lesser ecological validity, which puts its true applicability in a clinic into question.

It is our deduction that the active protocols presented by Vafadar and colleagues[63] are the only shoulder proprioception evaluation methods included in this review that are applicable in a clinic. Because of their use of common clinical tools, notably the goniometer, inclinometer, and laser pointer, and their relatively simple trigonometry-based scoring system, their methods could prove the most technically simple, as well as cost and time efficient for clinicians.

Proprioception relies on the multi-component sensory feedback from the tactile, vestibular and visual systems,[226, 274] which are then integrated and processed on both the conscious and unconscious levels.[275] In order to maintain a clinical orientation and a strong ecological validity for our recommendations regarding shoulder protocols, our systematic review focused on joint position sense and kinaesthetic awareness, both of which are conscious sub-modalities of proprioception.[274] We further chose to take a functional approach to the review and consequently, did not explore the possibility of the direct physiological measurement of proprioceptive neural pathways or the direct excitability of mechanoreceptors. Such methods generally involve complex and invasive experimental procedures that are not always readily available, nor applicable for clinicians.

3.6.2 Lack of standardization

Because of the lack of standardization of the included studies, we were unable to pool our findings into a meta-analysis. The clear lack of commonalities between the protocols could be due to the particular challenge of quantifying proprioceptive impairments of a joint as mobile as the shoulder. Shoulder proprioception protocols demonstrated inconsistencies with regards to warm-up sessions, number of evaluated trials, rest periods between trials and tactile feedback during limb manipulation. To overcome the lack of standardization, it is our recommendation that researchers and clinicians place greater emphasis on a detailed description of their protocols and their reproducibility, in order to encourage others to use the same protocol, thereby favouring benchmarking and increasing the statistical power and clinical applicability of their results.

3.6.3 Strength and limitations of the review

The strengths of this review include the exhaustive search of the literature including five scientific databases and hand searches. The use of validated critical appraisal tools facilitated our systematic evaluation of the quality of the studies and the psychometric properties of their protocols. The checklists employed also act as a limiting factor, seeing as the objective quality ratings of each article depended on the selected checklist. The QualSyst checklist was limiting for our review because of our inclusion of mostly methodological studies. Although the QualSyst is appropriate for both randomized and non-randomized studies, the total score does favour a randomized study design, thus potentially introducing a bias into our review which is comprised mostly of non-randomized studies. The COSMIN 4-point checklist was also limiting because of the descriptions of each scoring category, which were frequently either lacking or unclear, thus leaving room for interpretation, introducing a bias to the awarded scores and lowering our inter-evaluator level of agreement. Further limitations include the narrowing of the definition of proprioception assessment to JPS and kinesthesia, as well as only considering articles written in English or French. Future work should include the assessment of other aspects of joint proprioception, notably the detection of vibration, muscle tension, muscular force and velocities.

Moreover, only 19% (4/21) [63, 225, 252, 255] of the articles included in this systematic review were primary psychometric studies, meaning that their fundamental goal was to evaluate the robustness of their scientific method. The remaining 81% (17/21) of the included studies responded to a scientific question firstly and a psychometric inquiry secondly, potentially introducing a bias to the relative awarded scores of the modified checklists. Lastly, the lack of validity and responsiveness studies remains a major limitation for the conclusions that can be associated with measuring shoulder proprioception.

3.7 Conclusion

The included studies of this review suggest that protocols that use internal or external rotation at 90° of abduction at the shoulder are most reliable. According to our weighted average calculations, PJPS is the most reliable method for evaluating JPS and TTDPM for kinesthesia. The dynamometer currently has the greatest reliability potential; however, due to its cost, time-consuming installation, and the intricacies of the protocols, its applicability in a clinical setting remains questionable. The exact mechanisms of proprioceptive control at the shoulder remain unclear[225] and should thus be interpreted with caution.

Outcome measures for the evaluation of proprioception are limited by their complexity and use of intricate custom-built and electronic interfaces and are therefore difficult to apply to a clinical setting.[276]

3.7.1 Take Home Message for Clinicians

In order to quantifiably appreciate proprioceptive impairments and physical limitations in a clinical setting, it is imperative to employ evidence-based and psychometrically robust protocols. From the results of this review, we can encourage the preliminary use of a shoulder proprioceptive protocol which employs an isokinetic dynamometer, such as the Biodex, for either a passive protocol (JPS) or a detection of movement protocol (kinesthesia), evaluating the movements of internal or external rotation at 90° of shoulder abduction. Such methods support the strongest reliability measures over time and represent the best method for quantifying shoulder proprioceptive deficits in the clinic at this time.

3.7.2 Role of the Funding Source

This project did not receive funding from any sources.

3.7.3 Conflict of Interest Statement

No conflict of interest exists from any of the authors involved in this paper.

3.7.4 Author Contributions

All named authors have made a significant and substantial contribution to all aspects of the study. Each of the named authors provided a meaningful contribution to the conception, design, execution and interpretation of the study data in addition to writing, drafting and revising the paper itself. This paper is submitted with the agreement and approval of all authors.

Intraclass correlation coefficient calculation:

ICC(3) = BMS - EMS / BMS + *(k-1)*EMS

Weighted average for intra and inter-rater reliability ICC calculations:

Weighted average = SUMPRODUCT(ICC value, Total n)/ Total n (n = shoulders evaluate)

TABLE 5

Author and year	n	Proprioception Outcome	SEM (95) angular displacement error	MDC (95)
Vafadar et al. 2015	25	AJPS (ipsi) Inter & intra session	Laser pointer: • Inter: 0.6°-1.1° • Intra: 0.8°-1.1° Inclinometer: • Inter: 0.8°-1.4° • Intra: 0.9°-1.2° Goniometer • Inter: 0.8°-2° • Intra: 0.7°-2.2°	Laser pointer: • Inter: 1.8°-3° • Intra: 2.3°-3.1° Inclinometer: • Inter: 2.4°-3.9° • Intra: 2.7°-3.4° Goniometer • Inter: 2.4°-5.5° • Intra: 2.1°-6.2°
Lonn et al. 2000	10	AJPS and PJPS (ipsi) Inter session	Passive-active: 0.76° Passive: 1.02° Semi-passive: 0.51° Active: 0.54° Combined: 0.41°	Not reported
Sole et al. 2015	30	TTDPM & RPP (ipsi) Intra session	TTDPM: 0.15° RPP: 0.98°	Not reported
Anderson & Wee 2011	20	AJPS (ipsi) Inter session CRCP participants	<u>Affected limb</u> ABD in scapular plane at • 40° (low):1.3°±1.2° • 100° (high): 2.7°±2.6° <u>Non-affected limb</u> ABD in scapular plane at • 40° (low):2.0°±2.1° • 100° (high): 0.9°±0.9°	Not reported
Deng & Shih 2015	20	AJPS (ipsi) Inter session	<u>Non-Dominant:</u> Scapular depression • Rotation 0.15-0.41° • Displacement 0.03-0.08cm Scapular elevation • Rotation 0.21-0.49° • Displacement 0.08-0.26cm Scapular protraction • Rotation 0.46-0.57° • Displacement 0.03-0.10cm Scapular retraction • Rotation 0.39-0.68° • Displacement 0.04-0.20cm <u>Dominant:</u> Scapular depression • Rotation 0.16-0.62° • Displacement 0.02-0.13cm Scapular elevation • Rotation 0.27-0.93° • Displacement 0.09-0.26cm Scapular protraction • Rotation 0.16-0.39° • Displacement 0.06-0.23cm Scapular retraction	<u>Non-Dominant:</u> Scapular depression • Rotation 0.42-1.14° • Displacement 0.08-0.22cm Scapular elevation • Rotation 0.58-1.36° • Displacement 0.22-0.72cm Scapular protraction • Rotation 1.28-1.58° • Displacement 0.08-0.28cm Scapular retraction • Rotation 1.08-1.88° • Displacement 0.11-0.55cm <u>Dominant:</u> Scapular depression • Rotation 0.44-1.72° • Displacement 0.06-0.36cm Scapular elevation • Rotation 0.75-2.58°

			• Rotation 0.69-1.13° • Displacement 0.08-0.25cm	• Displacement 0.25-0.72cm Scapular protraction • Rotation 0.44-3.27° • Displacement 0.17-0.64cm Scapular retraction • Rotation 1.91-3.13° • Displacement 0.22-0.69cm
Nodehi-Moghadam et al. 2012	10	TTDPM & RPP (ipsi) Inter session	TTDPM: 0.25° RPP: 0.29°	Not reported
Suprak et al. 2006	22	AJPS (ipsi) Intra session	Plane/elevation (°) • 35/30 = 3.99° • 35/50 = 3.03° • 35/70 =3.51° • 35/90 =1.90° • 35/110 = 3.18° • 0/90 = 3.72° • 20/90 = 4.07° • 60/90 = 2.55° • 80/90 = 2.39°	Not reported
Kaya et al. 2012	11	AJPS (ipsi) Intra session	AJPS Eyes open = 4.5° Eyes closed =3.87°	Not reported

*(n) represents the number shoulders evaluated per protocol. Standard Error of Measurement (SEM) with a 95% confidence interval, Minimal Detectable Change (MDC) with a 95% confidence interval, abduction (ABD), chronic rotator cuff pathology (CRCP).

Table 5 Caption. Reporting of responsiveness psychometric properties of different shoulder proprioception protocols.

FIGURE 4

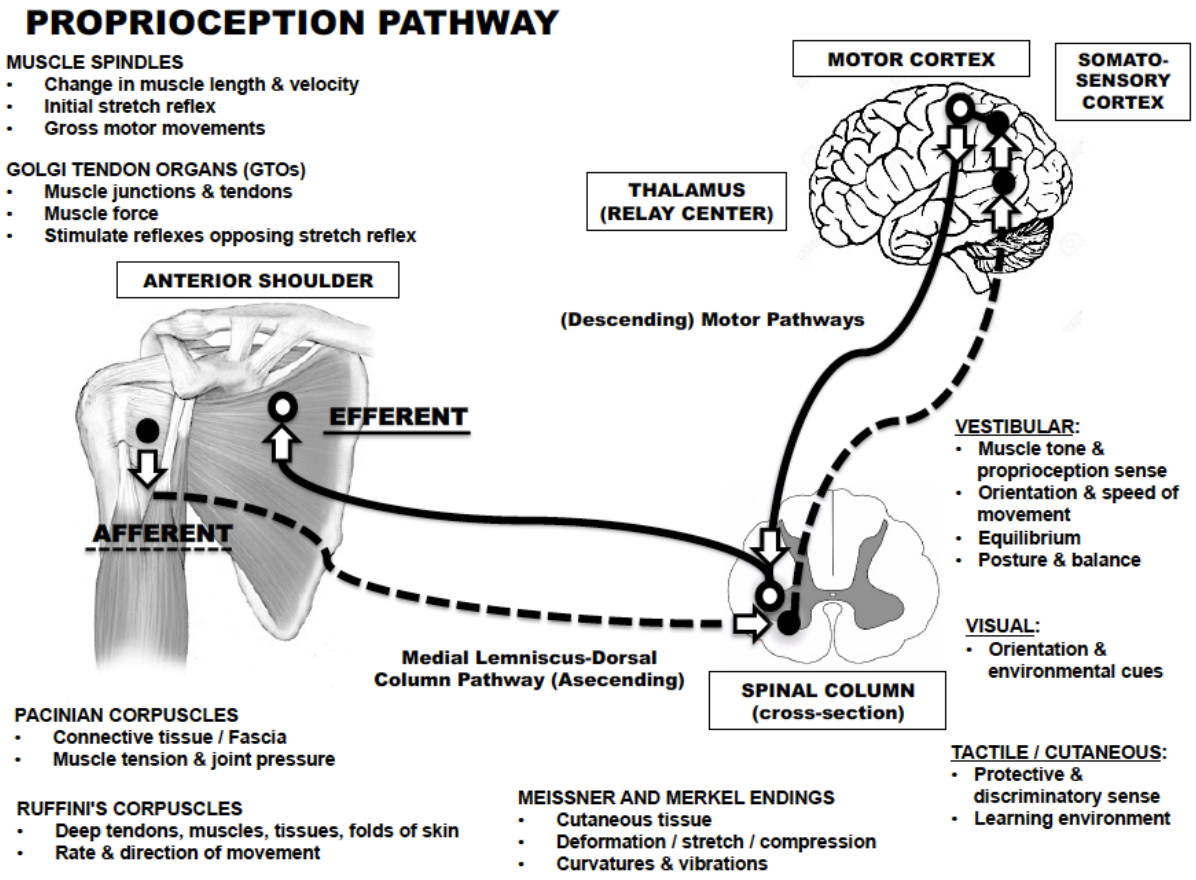


Figure 4 Caption: Graphical depiction of the shoulder proprioception pathway.

FIGURE 5

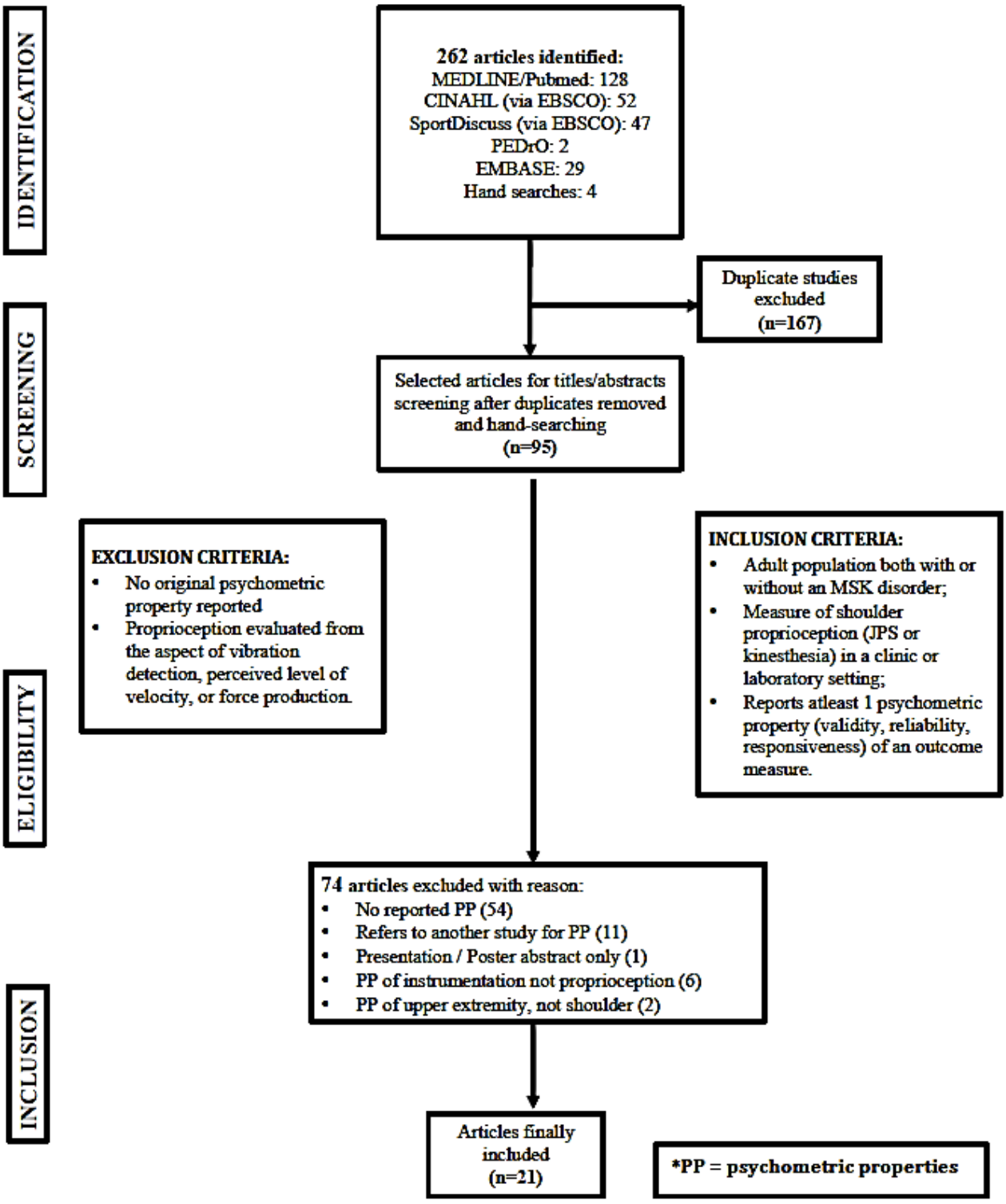


Figure 5 Caption: An organogram describing the literature selection process according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses).

FIGURE 6

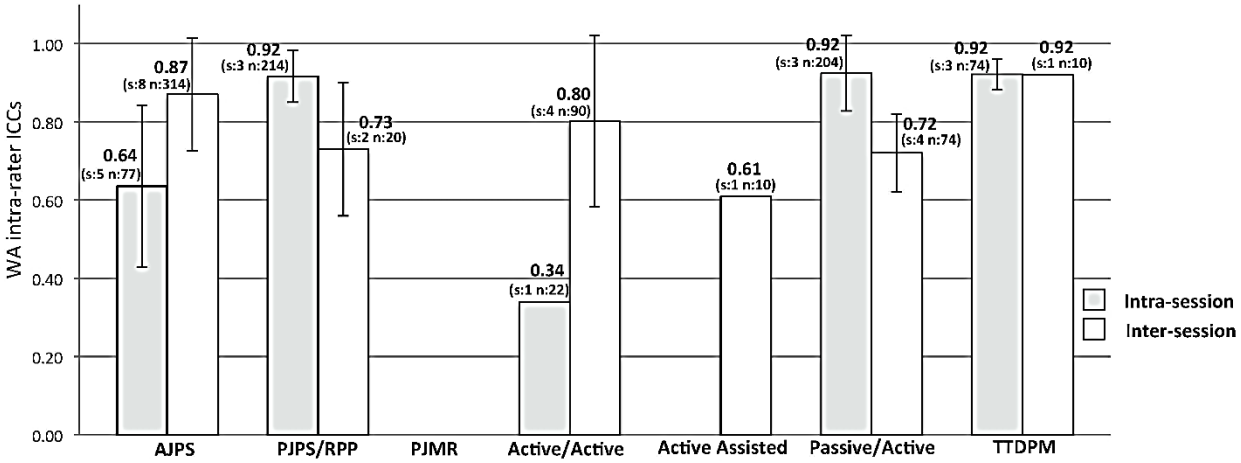


Figure 6 Caption: Weighted averages (WA) ICCs for intra-rater reliability of proprioception measures of the glenohumeral joint.

FIGURE 7

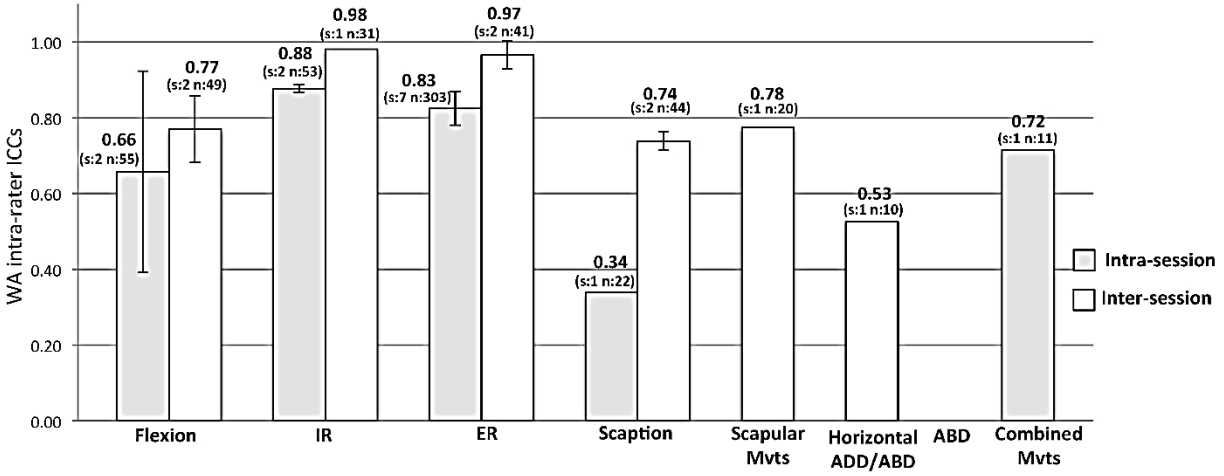


Figure 7 Caption: Weighted averages (WA) ICCs for intra-rater reliability for various movements of the glenohumeral joint.

FIGURE 8

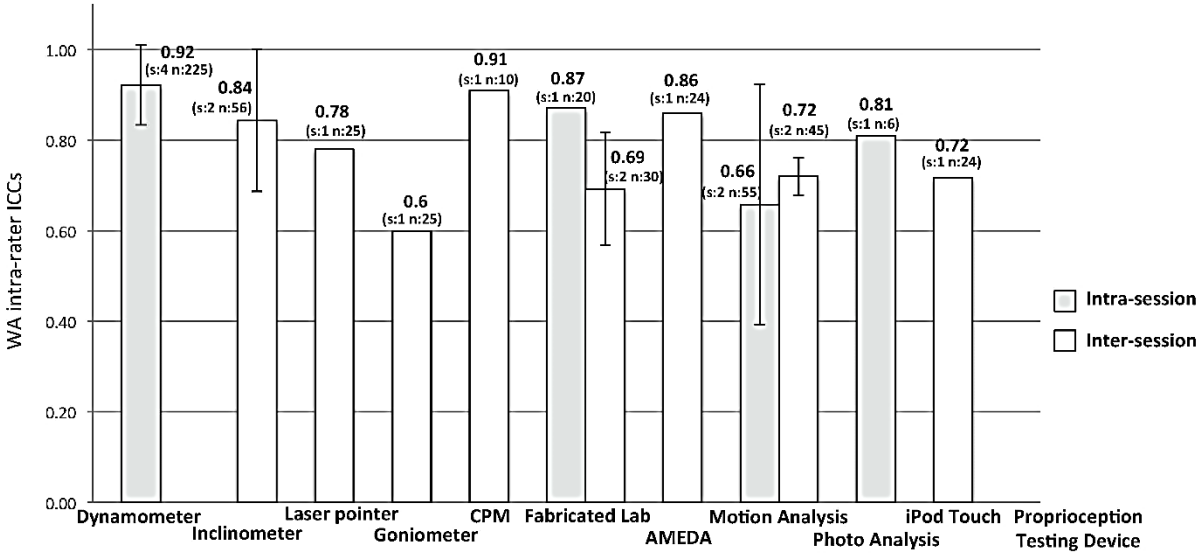


Figure 8 Caption: Weighted averages (WA) ICCs for intra-rater reliability for various proprioceptive equipment used for quantifying shoulder proprioception of the glenohumeral joint.

CHAPTER 4

THE EFFECTIVENESS OF AN UPPER EXTREMITY NEUROMUSCULAR TRAINING PROGRAM ON THE SHOULDER FUNCTION OF MILITARY MEMBERS WITH A ROTATOR CUFF TENDINOPATHY: A PILOT RANDOMIZED CONTROLLED TRIAL

Amanda L. Ager[1,2], Jean-Sébastien Roy[1,2], France Gamache[3], Luc J. Hébert[1,2,4]

1. Center for Interdisciplinary Research in Rehabilitation and Social Integration, Rehabilitation Institute, Quebec City, Quebec, Canada;

2. Department of Rehabilitation, Faculty of Medicine, Laval University, Quebec, Canada

3. Physiotherapy Department, Valcartier Garrison, Canadian Armed Forces

4. Department of Radiology/Nuclear Medicine, Faculty of Medicine, Laval University, Quebec, Canada.

Primary contact:

Ager, Amanda MSc(c) Biomedical and Clinical Sciences, MSc PT, BKin, Laval University; Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Quebec.

Address: CIRRIS-IRDPQ, 525, boulevard Wilfrid-Hamel, Quebec (QC) G1M 2S8, Canada

Telephone: 1-418-529-9141 ext. 6005, or +40 748 961 302

Email: amanda.ager.1@ulaval.ca

Secondary contact:

Hébert, Luc J. PT, PhD Laval University; Center for Interdisciplinary Research in Rehabilitation and Social Integration (CIRRIS), Quebec.

Address: CIRRIS-IRDPQ, 525, boulevard Wilfrid-Hamel, Quebec (QC) G1M 2S8, Canada

Telephone: 1-418-529-9141 ext. 6579

Fax: 1-418-529-3548

Email: lucj.hebert@fmed.ulaval.ca

This article has been submitted to the *Journal of Military Medicine* on 10 May 2018.

4.1 Résumé / Abstract

4.1.1 Résumé

Contexte

Bien que la douleur à l'épaule soit une des raisons principales pour consulter un médecin ou un physiothérapeute, la réadaptation de cette articulation demeure un défi. Parmi la population militaire, la douleur à l'épaule entraine souvent des congés de maladie et même une libération de service. Parmi les douleurs à l'épaule, la tendinopathie de la coiffe des rotateurs (CR) représente la source la plus fréquente de douleur. Bien que parmi les choix thérapeutiques en réadaptation pour traiter cette condition, il est fortement encouragé de prescrire des exercices, la façon optimale de recourir à cette méthode (type, dosage, individuelle ou en groupe) demeure incertaine. Le but de cet essai clinique randomisé à simple insu (l'évaluateur) était de comparer l'efficacité de deux programmes de rééducation de 6 semaines (un programme axé sur des exercices et une autre sur des soins usuels en physiothérapie) sur les symptômes et la capacité fonctionnelle et les limitations physiques chez des militaires souffrant d'une tendinopathie de la CR.

Méthodes

Trente-trois soldats en service actif au sein des Forces armées canadiennes (FAC) ont été assignés au hasard à l'une ou l'autre des interventions suivantes : 1) un programme standardisé et supervisé d'entrainement neuromusculaire et de contrôle moteur pour les membres supérieurs (Exp); 2) des soins usuels de physiothérapie (Ctl). Les variables principales de cette étude étaient les symptômes et la capacité fonctionnelle et les limitations physiques évalués à l'aide du questionnaire Disabilities of the Arm, Shoulder and Hand (DASH). La variable secondaire à l'étude l'indice Western Ontario Rotator Cuff (WORC). Toutes les variables ont été mesurées au départ (T0) et à 6 (T6) et 12 (T12) semaines après l'intervention. La comparaison des effets des interventions a été évaluée à l'aide d'une analyse per protocole (APP), analyse intention-traitement (AIT) et avec une analyse de variance à mesures répétées à 2 voies.

Résultats

Aucune interaction significative ($p \geq 0{,}101$) de groupe × temps ($p \geq 0{,}101$) n'a été démontrée pour les analyses APP ni AIT. Par contre, nous avons observé un effet de temps significatif ($p < 0{,}001$) pour le

questionnaire DASH et l'indice WORC. Bien qu'il n'y ait pas de différences statistiquement significatives entre les deux groupes au fil du temps, les scores obtenus pour le groupe Ctl pour toutes les variables à 12 semaines sont meilleurs que le groupe Exp.

Conclusion

Bien que la difficulté de recruter des sujets en peu de temps n'ait pas permis l'atteinte d'une puissance statistique suffisante, ces données préliminaires suggèrent que les deux approches de rééducation proposées conduisent à des améliorations comparables pour les deux groupes de patients traités. Ces résultats suggèrent donc que, chez des militaires, l'utilisation d'une intervention de groupe axée sur l'exercice pour une tendinopathie de la CR a le potentiel d'être aussi efficace qu'une approche un à un beaucoup plus exigeante en terme de temps de traitement. D'autres recherches avec un plus grand échantillon permettra de valider cette hypothèse et aussi de comparer les coûts et avantages en terme de ressources cliniques pour une telle approche utilisant des groupes supervisés.

4.1.2 Abstract

Background

Shoulder pain is among the leading reasons to consult a physician or physiotherapist today, yet continues to be a challenge to rehabilitate. This is true of a rotator cuff (RC) tendinopathy, the most important source of shoulder pain. This is also applies to an active military population, where shoulder pain is among the top reasons for sick leave or a potential discharge from service. Although rehabilitation trends encourage the use of exercise prescription for the management of an RC tendinopathy, the ideal method of clinical delivery (a group setting versus one-on-one) remains uncertain. The purpose of this single-blind (evaluator) pilot randomized clinical trial is to compare the effectiveness of two 6-week rehabilitation programs, a newly developed group neuromuscular training program and usual one-on-one physiotherapy care, on the symptoms and functional limitations of military members affected by a RC tendinopathy.

Methods

Thirty-three active soldiers with the Canadian Armed Forces were randomly assigned to either 1) a group intervention, a supervised Upper Extremity Neuromuscular Training Program (Exp) or; 2) an individual intervention, a one-on-one usual physiotherapy care (Ctl). The primary outcome was symptoms and functional ability evaluated using the Disability of Arm, Hand and Shoulder (DASH) questionnaire. Secondary outcomes included the Western Ontario Rotator Cuff (WORC) Index. Both were assessed at baseline (T_0) and 6 (T_6) and 12 (T_{12}) after baseline. The effects of the programs were assessed using 2-way repeated measures of variance for intention-to-treat (ITT) and per-protocol analyses.

Results

No significant group ($p \geq 0.16$) or group × time interactions ($p \geq 0.11$) were found for either ITT or per-protocol analyses. Although a statistically significant time effect ($p < 0.001$) was established for the DASH and WORC for both ITT and per-protocol analyses showing that both groups improved over time.

Conclusions

Although low recruitment precluded statistically significant conclusions, our preliminary data suggest that both rehabilitation approaches derived benefits over time. These findings suggest that the use of a group exercise-based intervention for a RC tendinopathy has potential to be just as effective as a one-on-

one approach for a military population. Larger sample sizes and further investigation are warranted regarding the cost and clinical resource benefits of such a supervised group approach.

Trial registration number ClinicalTrials.gov (NCT02926443).

Key words: Shoulder, motor control, supervised-exercise program, usual physiotherapy care, rotator cuff tendinopathy, military

4.2 Background

Shoulder pain is among the most common sites for musculoskeletal (MSK) symptoms, with up to one-quarter of the Western population reporting a problem at any one time.[16] These findings are echoed within a military population, where shoulder disorders are third in prevalence.[41, 277] Shoulder disorders have a professional and personal impact on soldiers and on the operational readiness of military capability as they lead to restricted duties, sick leave and the inability to deploy.[41, 130, 132] As with a civilian population, mechanisms of injuries related to shoulder disorders in the military are generally related to sports / physical training, rather than combat.[24, 25]

Among shoulder disorders, a rotator cuff (RC) tendinopathy remains the leading source of pain.[102, 104] The term RC tendinopathy is a clinical diagnosis that involves mechanical stress / trauma to the subacromial structures, including the RC tendons, the bursa, and the long head of the biceps tendon. Thus, the term RC tendinopathy indicates a clinical diagnosis, without knowing the specific underlying mechanisms of injury.[278, 279] Although the exact etiology of a RC tendinopathy is not entirely clear,[61] there is a growing consensus that an impingement occurs when the RC tendons are subjected to repetitive stresses, most often caused by repetitive overhead activities.[106]

The most common causes of an impingement include an abnormal superior and / or anterior migration of the humeral head within the glenoid fossa,[65, 66] and poor biomechanical control of the scapula along the thorax during arm elevation.[73] A neuromuscular dysfunction of the scapulohumeral (SH) and scapulothoracic (ST) musculature is said to alter the normal glenohumeral (GH) and ST arthrokinematics,[76] and predispose the development of a shoulder injury.[75-77] Currently, the literature encourages the application of exercise prescription for this population. Two recent systematic reviews[159, 160] concluded that exercise prescription is indeed an effective therapeutic approach. Such exercises include strengthening and exercises, which target scapular and GH stabilization through neuromuscular training.[141-144] Neuromuscular training can be understood as "... training which enhances the unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control".[9] This includes motor control and (re)learning, proprioceptive, and functional training for the upper extremities.

What is currently lacking in the realm of exercise prescription for a RC tendinopathy is whether the delivery method influences the effectiveness of the treatment, notably one-on-one with a physiotherapist (PT) or within a supervised-group setting. A supervised group-exercise approach has been suggested to be an effective solution for reducing waitlist time, and subsequently increasing access to rehabilitation care.[185, 280, 281] Presently, the effects of a group-supervised exercise approach are unclear with this population.

A clinical-group exercise approach has been well established with certain populations and areas of the body including the knee,[168-171] the thoracolumbar spine,[172] the cervical spine,[173] and the wrist.[174] The evidence for group programs involving the shoulder area is less clear. Programs are often either home-based programs, [116, 177, 179] or one-on-one supervised programs.[97, 138, 178, 180, 181] Few shoulder programs involve a structured and supervised group approach in a clinic. Moreover, the effects of a group-exercise program for shoulder pathologies among military members remains unknown.

The aim of this exploratory study was to evaluate the effectiveness of a group Upper Extremity Neuromuscular Training Program (UpEx-NTP) in the treatment of RC tendinopathy, within a Canadian military population, using a single-blind randomized controlled trial (RCT) design in comparison with usual physiotherapy care (UPC). We hypothesized that both the UpEx-NTP (Exp) and UPC (Ctl) groups will demonstrate statistically (p-value ≤ 0.05) and clinically (above the minimally clinically important difference [MCID]) significant changes in shoulder function and pain over a 6-week period and will be maintained over time, notably 12 weeks after the intervention. We further hypothesis that there will be no group $\times$ time interaction, suggesting that the improvement in a group setting or one-on-one will take place at a similar rate among military members with a RC tendinopathy.

This RCT was registered on ClinicalTrials.gov (NCT02926443).

4.3 Methodology

4.3.1 Participants

Participants were recruited via medical referrals from a physician or PT working at the military hospital located at the Valcartier Garrison in Quebec, Canada. All participants were active military personnel, aged between 18-60, with a clinical diagnosis of a RC tendinopathy. Participants were considered for this study if they had a Disability of the Arm, Shoulder, and Hand - Canadian French (DASH-CF) score greater than 15%, based on its MCID,[194] and if they presented with at least one positive finding in each of the following categories: 1) reported pain to the shoulder joint; 2) painful arc of movement during flexion or abduction; 3) positive Neer's or Kennedy-Hawkins Test; 4) pain on resisted external (lateral) rotation, abduction or Empty Can Test. The combination of criteria 2), 3) and 4) has a good diagnostic accuracy with sensitivity and specificity values $\geq$ 0.74 and +LR of 3-5.[158, 195] Individuals with symptomatic shoulders were excluded if they had any prior history of shoulder surgery, dislocations, fractures, capsulitis or demonstrate any systematic pathologies. Individuals were also excluded if they had confirmation of another diagnosis by imagery or declared an inability to attend the treatments sessions. This project was approved by the Quebec Rehabilitation Institute Research Ethics Committee as well as the Surgeon General's Health Research Board of the Canadian Armed Forces Health Services Group.

4.3.2 Study Design

This single-blind (evaluator), parallel-group RCT included two evaluation sessions, baseline (T_0) and week-6 (T_6), and an e-mail follow up at week-12 (T_{12}) by three independent evaluators. Each evaluator attended a familiarization and practice session (an estimated 3-5 hours) to become comfortable with all the equipment, special tests, and to standardize the physical examination process. The same participant was evaluated by the same evaluator pre and post intervention, and one evaluator was responsible for the follow up e-mail contact (T_{12}). At T_0, following written consent, data on demographics and maximum voluntary isometric contraction (MVIC) values were collected, and self-reporting questionnaires, including the DASH-CF questionnaire,[196, 197] the Western Ontario Rotator Cuff - French Canadian (WORC-CF) Index[194] and a 11-point Numerical Pain Rating Scale (NPRS),[211] were administered. Thereafter, participants were randomized and scheduled for their allocated treatments by an administrative assistant of the military physiotherapy clinic. All participants were scheduled to attend 2-

3 physiotherapy treatments per week over the following 6-week period at the physiotherapy clinic. Symptoms and disability / physical limitation outcomes (DASH-CF, WORC-CF) were revaluated at T_6 and T_{12}, whereas the MVIC[199, 200] and pain levels at rest (using the NPRS) were reassessed at T_6. A functional military task, the repeated sand-bag lift[202] was also evaluated at T_6. A Global Rating of Change (GROC) questionnaire[201] was administered at T_6 and T_{12}, respectively.

4.3.3 Randomisation and blinding

A researcher not directly involved in the data collection generated a randomization list using a random number generator (block randomization) with stratification according to sex (male/female). Group allocations were concealed in sequentially numbered sealed opaque envelopes, which were opened by the scheduling administrative assistant. Participants and treating PTs were instructed not to reveal their treatment allocation nor the treatments received throughout the project. Precautions were taken to ensure that the groups were physically separated from each other. Blinding was assessed using a question about group allocation following the final assessments. One PT was responsible for the supervision of the exercise program, whereas three different PTs were responsible for providing usual physiotherapy care at the military physiotherapy clinic.

4.3.4 Interventions

Participants took part in their respected 6-week rehabilitation program in different locations of the military physiotherapy clinic. The UPC guidelines were developed through a round-table discussion involving 3 researchers and 11 PTs from the clinic. The UpEx-NTP was developed through clinical experience and a thorough literature review over a two-year period.[81, 141, 146, 217, 282, 283] All treatments were documented in both groups and each participant received written explanations pertaining to their assigned treatments

4.3.5 The group-supervised Upper Extremity Neuromuscular Training Program

The experimental group (Exp) partook in a group-supervised neuromuscular training program which consisted of postural education, strengthening exercises, motor control and (re)learning exercises, and upper extremity functional tasks common for active military personnel. The UpEx-NTP program

consisted of 35-45 minutes of exercise, three times a week for 6 weeks (18 treatments, for an estimated total of 9-10 hours), supervised by a PT. No home exercises were given with this intervention. During the group program, participants had to choose one exercise to perform per station based on their ability while respecting their pain levels at 3/10 or less. It was possible for the participant to not complete all 11 stations within the 35-45 minutes, but as long as the participant was continuously challenging himself or herself, they were following the intention of the program. The participant was to be continuously moving throughout the program, and had to demonstrate a fatigue while performing the last few recommended repetitions of each station. The stations were organized by level of difficulty, meaning the first station is less physically challenging than the 11th station. The goal of the program was to be able to attempt the more difficult stations by week 5 or 6 of the program. The program allows for the individualized progressions of each station, under the guidance of the PT. Furthermore, the supervising PT could challenge the participant by encouraging more difficult exercises as long as their pain was managed at 3/10 or less throughout the entire program. If the exercise appears to be too difficult (observed compensations or pathological movement control) or causing too much discomfort, the supervising PT would correct the exercise or suggest a less stressful version of the exercise (as outlined by each station). All exercises were encouraged to be performed bilaterally. See supplementary appendix M for the full program.

4.3.6 One-on-one Usual Physiotherapy Care (UPC)

The control group (Ctl) received 2-3 physiotherapy treatments (30 minutes) per week in the clinic (total of 12 treatments) as well as an individualized home exercise program (HEP), to be performed 2-3 times per week. In total, this accounted for 6 hours of one-on-one physiotherapy care and an estimated 3-4 hours of home exercises, for a total of 9-10 hours of treatment over a 6-week period. From the round-table discussion, the following treatments have been accepted as reflecting the UPC practice for the treatment of an RC tendinopathy.

- Modalities: Ice only;
- Advice / recommendations: postural, relative rest, sleeping position, physical training;
- Range of motion exercises: active, active-assisted, passive, repeated movements such as the Mulligan or McKenzie approach;

- Stretching / manual therapy: mobilizations, manipulations, neural mobility, active release therapy, myofascial techniques;
- Strengthening or motor control exercises (to indicate equipment used and muscle group targeted);
- Other (Taping, postural, neuromuscular or proprioceptive training);
- Home exercise program (at the discretion of the treating PT; which could include stretching, strengthening, or motor control exercises, for example).

The treating PTs did not have any knowledge of the UpEx-NTP during this RCT.

4.4 Outcomes

4.4.1 Symptoms and disability

Symptoms and disabilities were assessed using the French Canadian versions of three self-reported questionnaires: the DASH-CF, WORC-CF and NPRS. The DASH, our primary outcome, assessed the entire upper limb symptoms and disability of the participants. The DASH questionnaire is valid (r = > 0.70),[197] highly reliable (ICC = 0.96 [95% CI, 0.93-0.98])[197] and demonstrates high reliability with French Canadian version (ICC = 0.93).[194] The DASH-CF also has a minimally clinically important difference (MCID) = 10.8 DASH points (sensitivity 79%, specificity 75%).[284] Our secondary outcome, the WORC Index, is a disease-specific quality of life questionnaire, evaluating the change in symptoms specific to a RC tendinopathy.[205] The WORC-CF is highly valid and reliable (ICC = 0.96),[194] supports an MCID of 245 points[205] of the total score, and has a minimal detectable change (MDC) of 19.1 points (moderate change).[285] Pain level was specifically assessed using the 11-point NPRS, where 0 represents "no pain" and 10 represents "worst pain imaginable". Participants were asked "*On a scale from 0 to 10, 0 being no pain at all and 10 being the worst pain imaginable, how would you rate your shoulder pain at this moment?"*. The French version of the NPRS is said to be moderately reliable (ICC range 0.74 - 0.76),[207] and a reduction of 2 points is said to be clinically important.[211]

4.4.2 Muscle impairment

Muscle impairment of each participant was assessed at T_0 and T_6 by evaluating their maximum voluntary isometric contraction (MVIC) of their shoulder external (lateral) rotators and abductors muscles, bilaterally, using the MEDup™ electronic hand-held dynamometer (HHD; MEDup™, Atlas Medic Inc.,

Quebec City, Quebec, Canada). The HHD has good concurrent validity to a stationary isokinetic dynamometer (r = 0.81),[200] and has excellent inter / intra examiner reliability for shoulder external (lateral) rotation (ICC = 0.96 / 0.96)[199] and shoulder abduction (ICC = 0.92 / 0.92).[199] The shoulder muscle strength evaluation was standardized and followed the protocols outlined in the Isometric Muscle Testing Manual by Hébert (2012).[210] All evaluators participated in a standardized training session for all shoulder muscle groups tested.

4.4.3 Physical limitations

Physical limitations were assessed with the military sand-bag lift test, performed only at T_6. Each participant was asked whether they felt capable of attempting the sand bag lift task, which includes lifting a 20 kg sand bag 30 times in the span of 3 minutes and 30 seconds.[202] If they provided verbal consent to perform the task based on their symptoms, and their reported shoulder pain was less than 3/10 at rest, the evaluator agreed to evaluate the military specific task. The number of sand bag lifts as well as the time to completion was recorded by the evaluator. Although this is not an established valid or reliable measure for shoulder function, it is a standardized military test, which is uniquely part of the CAF physical fitness standard and is evaluated annually. This task was used as a clinical benchmark to assess the participants' level of military function and their ability to engage in their soldiering duties.

4.4.4 Perceived level of change

Perceived level of change was evaluated using a GROC (Global Rating of Change) questionnaire. The GROC uses a numerical score to reflect the perceived change of the participants' symptoms (1 = worse, 2 = stable, and 3 = better). If an improved (1) or worse (3) state was indicated, a numerical value of 1 - 7 was indicated by the participant, where 1 reflected "minimal improvement" and 7 indicated "great improvement". If the participant indicated a worsening of their symptoms (1 = worse), the scale of 1-7 will reflect the level of deterioration of their condition. The GROC has an excellent reliability (ICC = 0.9) and has a MCID of 2 points.[208, 209]

4.4.5 Data analysis

Descriptive statistics were used for all outcome measures at each measurement of time to summarize results. Baseline demographics were compared (Independent t-test and chi-square tests) to establish the comparability of groups. All data was tested to check the distributional assumptions for the inferential statistical analyses. An intention-to-treat (ITT) and per-protocol analysis were performed for the DASH-CF and WORC-CF, pain levels at rest, and the measurements of strength for both shoulders. The effects of the interventions on the DASH-CF and the WORC-CF were analyzed using a 2 × 3 (Exp + Ctl groups × T_0, T_6, and T_{12}) repeated measure analysis of variance (ANOVAs). Similarly, a 2 × 2 × 2 (group × time × shoulder) repeated measure ANOVAs was used for MVIC and a 2 × 2 (group × time) ANOVA was used for the NPRS pain rating to compare values from T_0 and T_6 for both groups. Descriptive statistics and a chi-squared test were used to analyze the results from the GROC questionnaire, while an independent t-test was used for the comparability of groups for the sandbag lift. Descriptive statistics were used to quantify level of compliance for physiotherapy treatments. Compliance was assessed as number of treatments attended by each participant and normalized to 100%. Descriptive statistics were reported (median ± standard deviation) as well as the associated confidence intervals (95%CI) for each group. Furthermore, a chi-square test was used to evaluate the difference between compliance levels for each group. All analysis was performed using SPSS version 24.0 (SPSS, Chicago, Ill) for Mac software, with all α values set to 0.05.

4.5 Results

Between January 2015 and June 2017, a total of 80 active military members were contacted by telephone for the participation in our RCT (Figure 9). Eighteen individuals were excluded at this stage, whereas 29 were excluded during the in-person objective evaluation (total excluded: 47). Therefore, 33 active military members were randomly allocated to a treatment group (Exp: 16, Ctl: 17).

Before the completion of the 6-week intervention, one participant dropped out of the Exp group and 5 from the Ctl group (total of 6 drop-outs). Reasons for the drop-ops included two confirmations of another diagnosis by imagery (including one acromioclavicular (AC) instability and one extensive calcification of the RC tendons), three participants who could not attend the treatment sessions due to work obligations

of military tasks or exercises, and one voluntarily abandonment due to a self-reported resolution of symptoms.

Each participant was contacted up to 3 times by e-mail or telephone for the 12-week follow-up. If a response was not successful, this was considered missing data and the results from T_6 for that participant was used for the ITT analysis. At the 12-week follow-up, 13 participants responded from the Exp group (missing data n=2), whereas 8 responded from the Ctl group (missing data n=4). The ITT analysis includes the data from 33 participants (Exp: 16, Ctl: 17) and the per-protocol analysis includes the data from 21 participants (Exp: 13, Ctl: 8) who completed the treatment originally allocated to them from baseline to the end of the study at 12 weeks.

See Table 6 for an outline of the baseline demographics of the included participants (n=33), outlined by treatment group allocation. Both groups were similar in all baseline demographics, seeing as no statistically significant differences were found ($p = 0.1 - 0.9$).

FIGURE 9

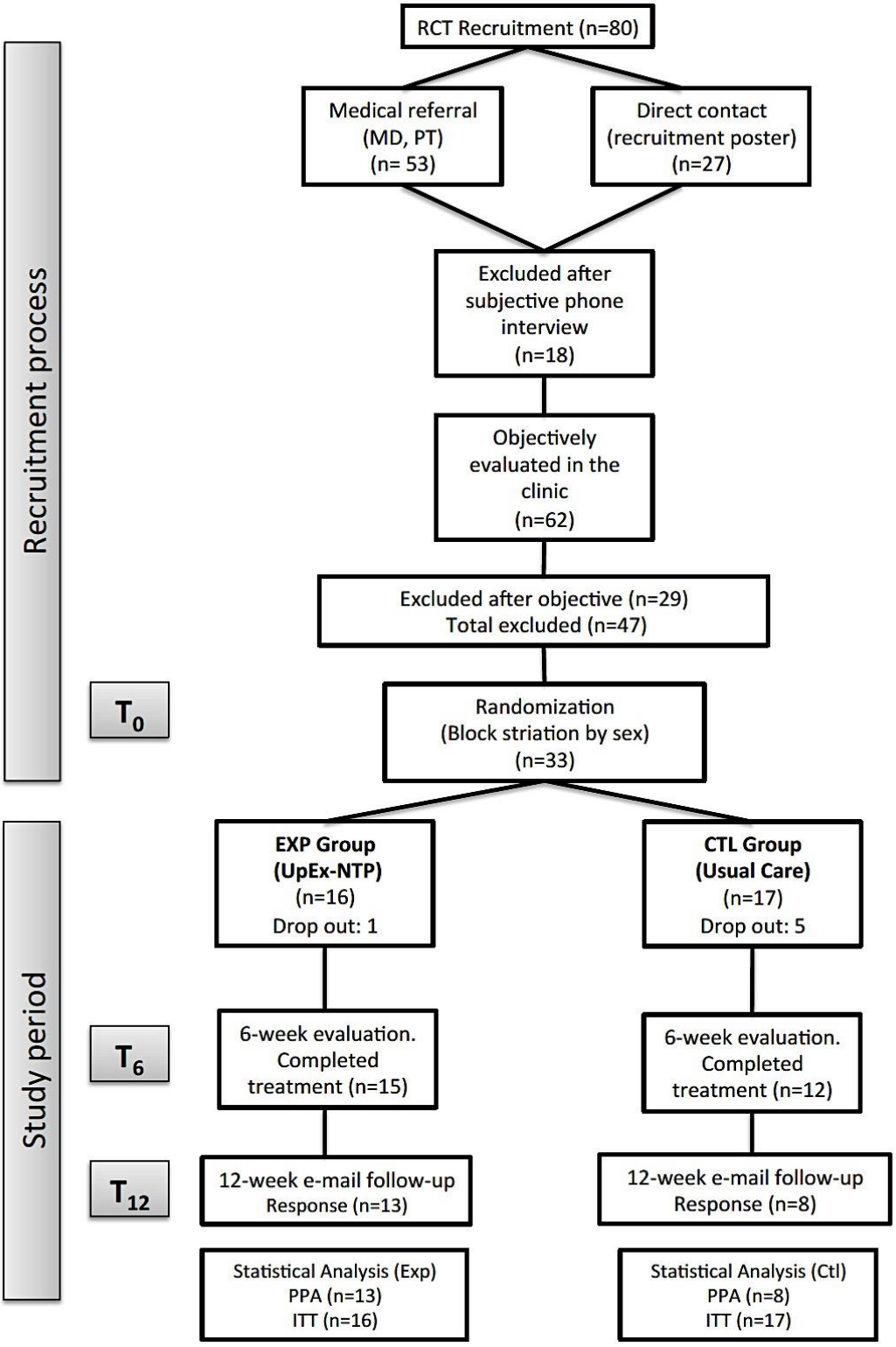


Figure 9 Caption: Recruitment algorithm for an intention-to-treat (ITT) and per-protocol analysis.

TABLE 6

	Exp Group (UExNTP) (n = 16)	Ctl Group (UPC) (n = 17)	Independent t-test or chi-square test for demographics
Age ($\bar{X}$ ± SD)	33.4 ± 9.5	36.9 ± 7.1	p = 0.2
Sex male / female	16 / 0	16 / 1	p = 0.2
Height (cm) ($\bar{X}$ ± SD)	174 ± 6	173.2 ± 6.1	p = 0.27
Weight (kg) ($\bar{X}$ ± SD)	95 ± 21	86.2 ± 13.7	p = 0.1
Smoker yes / no	1 / 15	3 / 14	p = 0.2
Dominance R / L	15 / 1	15 / 2	p = 0.4
Affected Shoulder R / L / Both	8 / 7 / 1	8 / 8 / 1	p = 0.9
Length of symptoms (months) ($\bar{X}$ ± SD)	23.17 ± 41.5	38.3 ± 50.5	p = 0.5
Years of military service ($\bar{X}$ ± SD)	12.8 ± 7.2	12.1 ± 8.74	p = 0.8
Service element Army /Navy / Air	15 / 1 / 0	17 / 0 / 0	p = 0.4

Table 6 Caption: Means and standard deviations of baseline characteristics of the participants, according to intention-to-treat analysis (n = 33). Also presented are the results from the statistical analysis, demonstrating no statistical significant differences between the Ctl and Exp groups for their baseline demographics.

4.5.1 Level of symptoms and disability

For the DASH-CF, neither the ITT nor per-protocol analysis showed any statistically significant group ($p \geq 0.4$) or group × time interaction ($p \geq 0.13$). Both analyses did however demonstrate a significant time effect, meaning an improvement in the mean scores (time effect; $p < 0.000$) at T_6 and T_{12}, when compared to T_0. As for the WORC-CF Index, the total WORC scores ITT and per-protocol analysis revealed no statistically significant group ($p \geq 0.1$) or group × time interaction ($p \geq 0.1$). Again, both analyses did demonstrate a significant time effect, meaning an improvement in the mean scores (time effect; $p < 0.0001$) at T_6 and T_{12}, when compared to T_0. See Table 7 for mean scores of the DASH-CF questionnaire and WORC-CF Index of both groups over time.

FIGURE 10

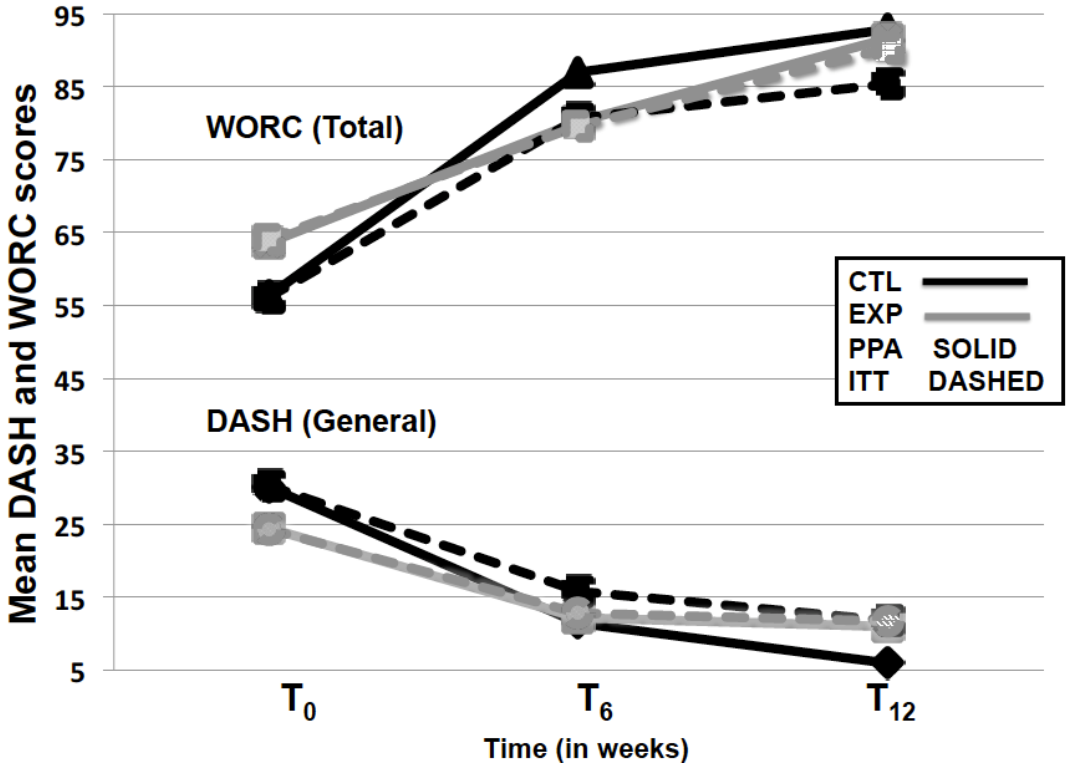


Figure 10 Caption: Mean scores of DASH-CF and WORC-CF over time (T_0, T_6, and T_{12}), per-protocol analysis (PPA: n = 21) and intention-to-treat (ITT: n = 33). A higher WORC Index score represents a functional improvement, whereas a lower DASH score represents improvement.

TABLE 7

Outcome measures		Ctl Group (UPC) PPA (n=8) Mean score change from baseline	Exp Group (UpEx-NTP) PPA (n=13) Mean score change from baseline	Ctl Group (UPC) ITT (n=17) Mean score change from baseline	Exp Group (UpEx-NTP) ITT (n=16) Mean score change from baseline
DASH (General)	T_0 (mean baseline score)	30.14 (±11.9)	24.4 (±11.9)	30.3 (±11.4)	24.3 (±11.5)
	T_6	Δ -18.68 (±8.8)	Δ -12.3 (±7.7)	Δ-12.8 (±13.4)	Δ-11.5 (±10.3)
	T_{12}	Δ -24.2 (±5.1)	Δ -13.5 (±9.9)	Δ-16.4 (±14.9)	Δ-12.6 (±10.3)
	Time effect η^2	0.56	0.28	0.3	0.26
DASH (Sports)	T_0 (mean baseline score)	54.5 (±28.9)	52.1 (±35.6)	55.8 (±26.2)	50.0 (±34.9)
	T_6	Δ -28.5 (±26.2)	Δ -24.9 (±23.4)	Δ-15.8 (±28.5)	Δ-18.4 (±35.5)
	T_{12}	Δ -38.4 (±19.3)	Δ -20.9 (±31.4)	Δ-21.3 (±27.2)	Δ-15.3 (±37.3)
	Time effect η^2	0.3	0.11	0.19	0.11
DASH (Work)	T_0 (mean baseline score)	30.7 (±20.4)	34.2 (±32.1)	26.7 (±20.5)	34.0 (±31.0)
	T_6	Δ -20.3 (±19.8)	Δ -22.2 (±14.8)	Δ-14.0 (±17.6)	Δ-20.8 (±24.1)
	T_{12}	Δ -26.04 (±8.9)	Δ -20.9 (±20.5)	Δ-18.0 (±18.9)	Δ-20.8 (±24.1)
	Time effect η^2	0.28	0.17	0.23	0.15
WORC (Total)	T_0 (mean baseline score %)	56.3 (±14.2)	63.6 (±19.5)	56.1 (±13.4)	64.1 (±18.9)
	T_6	Δ +30.7 (±10.2)	Δ +16.6 (±14.3)	Δ+21.7 (±20.8)	Δ+15.5 (±14.1)
	T_{12}	Δ +36.6 (±9.4)	Δ +28 (±8.5)	Δ +25.8 (±23.8)	Δ+26.2 (±20.2)
	Time effect η^2	0.7	0.42	0.4	0.36

Data presented as Mean (± standard deviation). Δ Denotes a change from the baseline score (indicated at T_0 in bold)
DASH: Disabilities of the Arm, Shoulder and Hand questionnaire (lower score indicates higher disabilities, therefore a negative change from baseline indicates an improvement); WORC: Western Ontario Rotator Cuff index (higher score indicates higher functional capacity, therefore a positive change from baseline indicates an improvement).

Table 7 Caption: Mean scores and standard deviations of DASH-CF and WORC-CF Questionnaires in relation to baseline values for the Ctl and Exp Groups (PPA n = 21, ITT n = 33)

As for the shoulder pain level at rest (Figure 11), there were no observed group or group × time interaction ($p \geq 0.18$) for pain levels for a ITT or per protocol analysis. A statistically significant time effect ($p = 0.001$) was observed. Of note, the Ctl group demonstrated a clinically significant decrease in pain of 2.4 points at T_6, whereas the Exp group also demonstrated a decrease in pain over time of 1.4 points at T_6, although not clinically important.

FIGURE 11

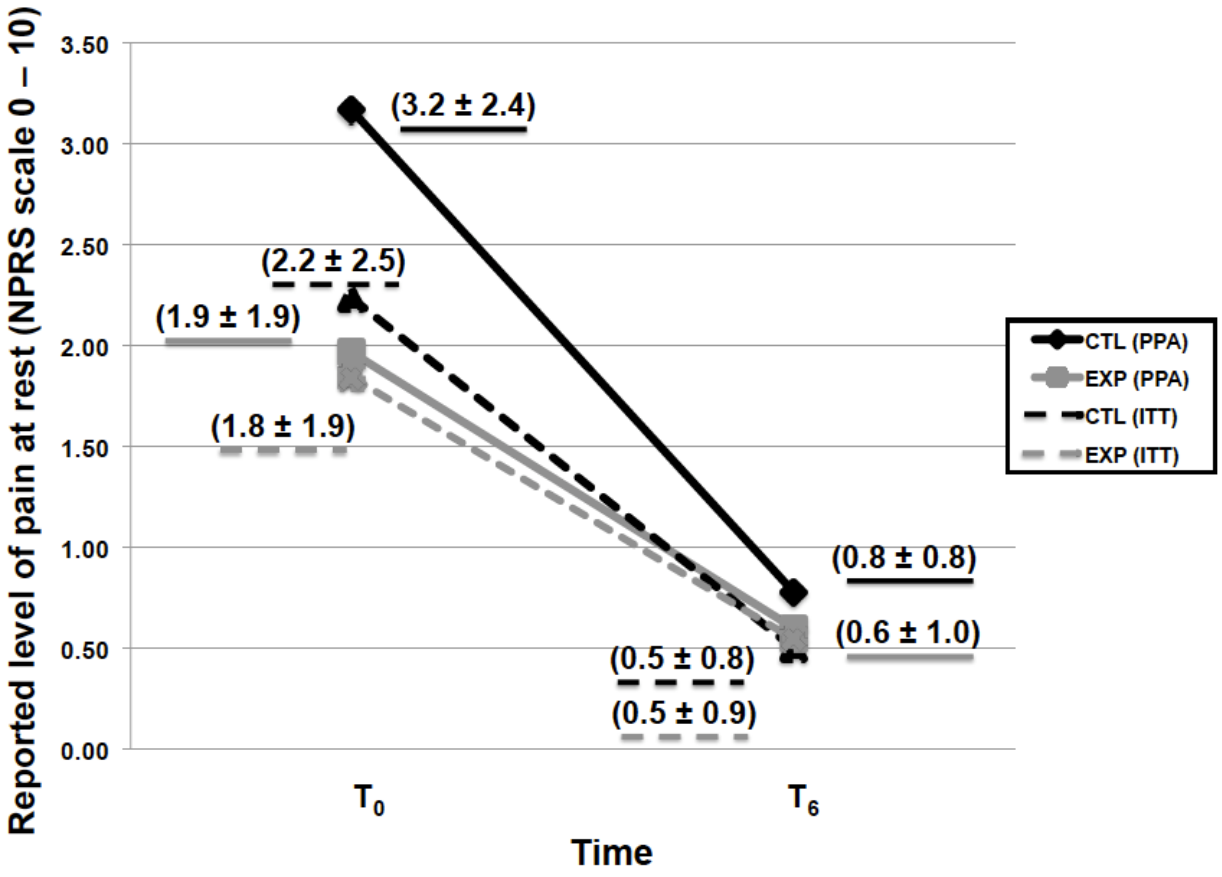


Figure 11 Caption: Pain levels at rest for both groups at T_0 and T_6, represented as ($\bar{X} \pm SD$), per protocol analysis (PPA: n = 21) and intention-to-treat (ITT: n = 33) of the injured shoulder. Using the NPRS scale where 0 represents "no pain at all" and 10 represents "worst pain imaginable".

4.5.2 Muscle strength impairments and physical limitations

As detailed in Table 8, overall, there was a mean increase of the MVIC for abduction strength with the Ctl group of 8.4 ± 11.5 Nm, compared to 3.9 ± 6.4 Nm with the Exp group. Similarly, there was a mean increase of the MVIC for external rotation strength with the Ctl group of 7.3 ± 8.7 Nm and 4.0 ± 7.5 Nm, with the Exp group. Statistically significant time effects were noted in shoulder abduction strength, for both the injured and healthy shoulder in both groups (Table 8). No statistically significant group × time × shoulder interaction was found ($p \geq 0.1$).

TABLE 8

		Exp Group UpEx-NTP (n=13) Mean Score		Ctl Group UPC (n=8) Mean Score		Exp Group UpEx-NTP (n=16) Mean Score		Ctl Group UPC (n=17) Mean Score	
		Per-protocol analysis (PPA)				Intention-to-treat (ITT) analysis			
Outcome measures	Time	Injured	Healthy	Injured	Healthy	Injured	Healthy	Injured	Healthy
Isometric strength (MVIC) of ABD	T_0	56.0 ± 17.4	57.1 ± 9.9	41.9 ± 15.6	50.6 ± 15.5	55.2 ±17.2	56.8 ±17.0	41.1 ±16.8	50.8 ±18.3
	T_6	60.2 ± 16.0	57.5 ± 16.9	48.5 ± 18.3 †	49.5 ± 18.0	59.1 ±16.2	57.1 ±21.3	45.9 ±19.0	50.0 ±19.3
Time effect η^2		0.02†	0.008†	0.05†	0.002†	0.014†	0.000†	0.034†	0.001†
Isometric strength (MVIC) ER at 90° of ABD	T_0	33.4 ± 9.4	34.4 ± 5.0	28.0 ± 8.9	33.0 ± 11.1	32.8 ±9.3	33.7 ±10.0	28.0 ±10.1	33.6 ±13.1
	T_6	37.6 ± 8.2	39.1 ± 8.2	34.2 ± 13.0	37.6 ± 13.7	36.8 ±8.5	38.1 ±12.8	32.6 ±13.2	37.0 ±14.8
Time effect η^2		0.07†	0.1	0.11	0.05†	0.05†	0.085	0.082	0.032†

Maximum voluntary isometric contraction (MVIC) values reported in Newton-meters (Nm)
ABD: abduction, ER: external rotation.
No statistically significant results have been found for a time or group × time interaction, nor for a group × time × shoulder interaction for either ABD or ER isometric strength.
†indicates a significant time effect ($P < 0.05$).

Table 8 Caption: Mean scores and standard deviations of maximal isometric voluntary contractions (MIVC), expressed as muscle strength in Newton meters (Nm) of injured and healthy shoulder for the Ctl and Exp Groups at T_0 and T_6 (per-protocol analysis, n = 21 and intention-to-treat, n = 33).

With regard to physical limitations, all of the participants in the Ctl group (12/12 - 100%) attempted the sand bag lift, with a mean time of 71.6 ± 26.7 seconds, whereas 12/15 (80%) of the Exp group attempted the task with a mean time of 70 ± 24.1 seconds. Three participants from the Exp group did not attempt the task due to a painful shoulder, low back pain, or reported pain to the contralateral elbow. The Ctl group had a mean pre-pain level of 0.1/10 and a post-pain level of 0.64/10 for the injured shoulder after the sand bag lift. The Exp group had a pre-pain level of 0.3/10 and a post-pain level of 0.73/10. An Independent t-test revealed no statistically significant difference between the groups ($p = 0.8$) for the performance in time (seconds) of the sand bag lift.

4.5.3 Perceived Level of Change, adherence to treatment schedule, and blinding

Perceived level of change using the GROC scale was high for both the Ctl and Exp group at both T_6 and T_{12}, respectively (Figure 12). However, a comparative chi-square test revealed no statistically significant differences between the groups at either T_6 or T_{12} ($p \geq 0.15$). The median level of compliance for the Ctl group demonstrated an attendance of 87.5% (± 23.4%) with a 95% CI [64.3, 94.1] of the treatments, whereas the Exp group had a median level of compliance of 66.7% (± 22.9%) with a 95% CI [57.7, 83.0]. A comparative chi-square test revealed no statistically significant differences between the groups ($p = 0.3$) for treatment adherence. Evaluator blinding was successful in (26/27) 96% of the treatment allocations for the participants. One participant did mention their intervention to the evaluator during their 6-week follow-up.

FIGURE 12

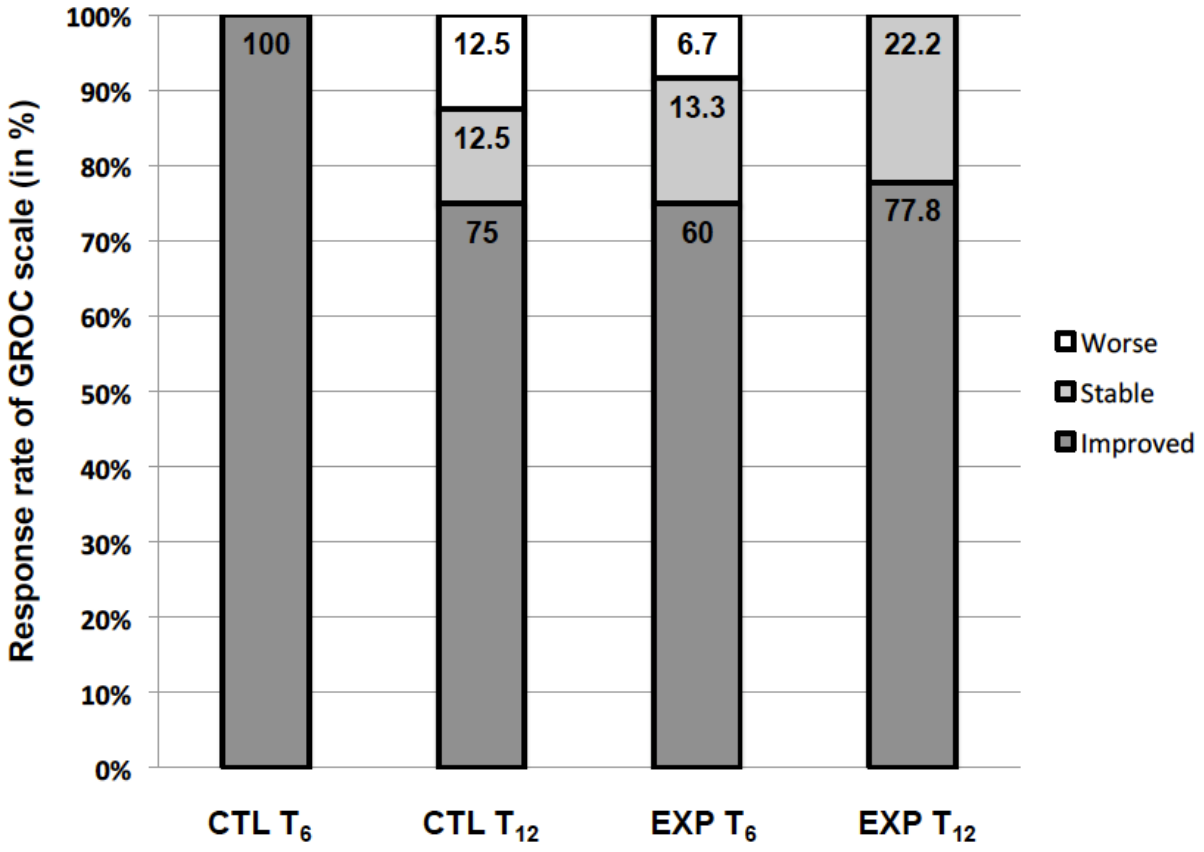


Figure 12 Caption: Results of secondary outcome measure: perceived level of change (GROC), represented as response rate (%) for both groups, as a per-protocol analysis (n = 21).

4.6 Discussion

To our knowledge, this is the first pilot RCT comparing a structured and supervised-group exercise program to usual physiotherapy care for the management of a rotator cuff tendinopathy among active military members. Our original hypothesis of both groups demonstrating improvements over time was confirmed. Both groups demonstrated clinically important differences at T_6, by surpassing the MCID for both the DASH questionnaire and WORC Index. Both groups also demonstrated a significant decrease in reported pain over time, which was clinically significant only for the UPC (Ctl) group. Globally, the UPC group demonstrated marginally better improvements in all outcome measures at T_6 and T_{12}, although not statistically significant compared to the UpEx-NTP (Exp) group.

4.6.1 Multimodal versus exercise-based treatments

The current literature presents mixed results with regards to an effective treatment approach for a RC tendinopathy. Several systematic reviews encourage the use of multimodal care,[135, 141, 145, 286] while another reports low to moderate improvements at best.[146] Additionally, several studies advocate that an exercise-based approach is most favorable for the management of a RC tendinopathy.[142, 157, 159, 160] There is growing evidence to suggest that exercise-based therapies are the most efficient and cost-effective conservative treatment approaches among this population.[146, 147] Seeing as our usual care PTs were able to provide exercise prescription at their clinical discretion, in addition to hands-on therapy, it is difficult to attribute the functional gains of the Ctl group to exercise alone. If this was the case, our Exp group, receiving solely active exercises, could have demonstrated comparable gains. Furthermore, our usual care physiotherapists were able to allocate home exercises to their interventions, at their discretion. The group program participants (Exp) did not receive home exercises in addition to the structured program. This decision was made in order to equalize the number of treatment hours between the two groups during the 6-week intervention period. Further investigation into the effectiveness of home exercises within this group program is warranted.

Affirmative conclusions are difficult to state at this point, seeing as a larger sample size could reveal contradictory or supportive results. There is developing support to suggest that an exercise program could be just as effective as one-on-one usual physiotherapy care.[282,104] Our findings in this exploratory study are in-line with emerging evidence specifying that an exercise-based approach can encourage symptomatic and functional changes over time for individuals with a RC tendinopathy.

4.6.2 A supervised approach for common MSK conditions

Presently, there is elementary support for the implementation of a supervised-exercise program for the management of several MSK conditions and specific populations. Research supports programs for post-surgical rehabilitation,[161] cardiovascular retraining,[162-165] specific target groups such as the elderly,[166, 167] as well as structured protocols for MSK dysfunctions for the knee,[168-171, 287] the thoracolumbar spine,[172] the cervical spine,[173] the wrist,[174] and the shoulder.[97, 138, 152, 175-178] Inspite of the growing use of supervised approaches for common shoulder pathologies, published results are currently lacking for supervised-group exercise. Several of the reported structured shoulder protocols are either home exercise

programs[176, 177, 179, 288] or supervised one-on-one in a clinic,[97, 180, 181, 289] and not delivered in a group environment. There is an extent need for quality studies investigating the effects of a group intervention for the rehabilitation of common MSK disorders. This is particularly important for a military population. It is generally accepted that the military places greater emphasis on group activities and the development of a team over the individual;[290] therefore, a group exercise approach may prove effective for this population.

4.6.3 Group exercise and access to physiotherapy services

Although there is support for the effectiveness of supervised programs, methodological studies evaluating the merit of group programs or exercise classes are lacking. A preliminary review of the literature reveals a few programs for populations such as pregnant women,[291] the elderly,[292, 293] and individuals with chronic low back pain,[294] for example. The literature for group interventions addressing common shoulder pathologies is limited. This is surprising given the potential for a group approach to be a feasible management strategy for decreasing wait list time and increasing access to rehabilitative care in a clinical setting.[185, 280, 281]

A group treatment approach could potentially promote rehabilitative care that is just as efficient, and potentially more cost effective, in terms of materials, time, and personnel, than the current one-on-one care model. Further research is needed to determine the suitability of certain MSK conditions and populations to be managed within a group setting, as well as to establish at what stage of rehabilitation a group approach is most optimal. Our preliminary results demonstrate potential for a group setting to be comparable to one-on-one care for the rehabilitation of shoulder pain, by suggesting similar gains in functional and self-reported outcomes, over time for both of our intervention groups. Although limited by our small sample size, our exploratory project should embolden researchers and clinicians to consider the possibility of group rehabilitation.

4.6.4 Strengths and limitations of this study

The strength of the present study is the implementation of a unique supervised neuromuscular training program for the management of a RC tendinopathy. This platform allowed for individualized progressions of a series of exercises, while being guided by a PT. The structure and clear parameters of

the program could inspire other clinicians and researchers to investigate the effectiveness of the program with a larger sample size.

This study also includes some limitations. This study was conducted in a population that presents a high homogeneity in terms of age range, sex, and type of work, which decreases the external validity of this study. Our group-supervised program should have included home exercises, in order to further minimize the differences between the control and experimental conditions during our 6-week interventions. Also, the recruitment and adherence to the project schedule proved challenging for the military population, who are often deployed on tasks and exercises. The drop-out rate was much higher than anticipated, making strong statistical inferences a challenge. Although there were significant difficultly with recruitment, we were able to record relevant preliminary data that will pave the way for future studies. Based on our primary outcome, the DASH questionnaire, (G*Power 3.1.7; effect size: 0.846, $\alpha = 0.05$, $\beta = 0.80$, SD = 13 DASH points, clinically important difference (CID) = 11 DASH points), the target sample size for a future study should be of at least 23 participants per group, considering an expected lost at follow-up of 20%. This was our projected recruitment target, as reflected by our registration with ClinicalTrials.gov. The outlined challenges resulted in 33 participants being recruited for this study.

4.6.5 Take home message for clinicians

- There is potential for a group exercise program to be just as effective as one-on-one physiotherapy care for the management of a rotator cuff dysfunction;
- A supervised group-structured program is worth further investigation, as it may have potential to increase access to physiotherapy care while decreasing wait-time for treatment;[185, 280, 281]
- We encourage clinicians to use our UpEx-NTP (Supplementary Appendix M).

4.6.6 How to increase adherence to a group exercise program

- Implement a brief tele-support (phone call or e-mail) reminder to enhance patient attendance to treatment;[295]
- Highlight the benefits of the exercises to the patient, incorporating the program into a well-established routine, and implement more intensive monitoring during the program;[296]

- Establish realistic treatment parameters, such as twice a week in-clinic treatments with a complementary home exercise program;
- Set specific patient goals considered as a minimal requirement to ensure effectiveness of treatment;
- We recommend the program parameters to reflect twice a week, up to 45-minute sessions, with a complementary home exercise program, in order to increase patient compliance.

4.7 Conclusion

Both the group-supervised program and usual one-on-one physiotherapy care approaches resulted in statistically and clinically significant improvements over time for an active military population affected by a rotator cuff tendinopathy. Our preliminary results suggest that further investigation is needed to determine the effectiveness of a structured and supervised-group program for the management of a RC tendinopathy as well as other MSK shoulder conditions. Our research hopes to encourage the exploration of the potential economical argument for the use of supervised-group rehabilitation programs for the management of common MSK conditions.

4.7.1 Acknowledgements

The authors would like to recognize the outstanding contributions by the Canadian Armed Forces, particularly the physiotherapy department at Valcartier Garrison. The authors would also like to highlight the unique contributions of the following physiotherapists Pierre-Marc Vézina, Sophie Bernard, Valérie Charbonneau, Myriam Cyr, and Marie-Élise Prémont. We would further like to highlight the support from the military chain of command at the Valcartier base hospital as well as Nancy Garneau and Stéphanie Grenier who made sure the project ran smoothly on a day-to-day basis. The project would not have been a success without all of your hard work and dedication to evidence-based rehabilitation.

4.7.2 Funding

Research reported in this publication was supported by the 4.2.1 program from the *Réseau provincial en adaptation-réadaptation* and *Ordre Professionel des Physiothérapeute de Québec* (REPAR-OPPQ) under the award number 2016-17-#2. Additional support was provided by the Centre for Interdisciplinary

Research in Rehabilitation and Social Integration (CIRRIS) and Laval University in the form of a student bursary. JSR was supported by salary awards from the Canadian Institutes of Health Research (CIHR).

4.7.3 Availability of data and materials

The datasets used and / or analysed during the current study are available from the corresponding author upon reasonable request. The UpEx-NTP is available as a Supplementary Appendix.

4.7.4 Ethical Approval

Quebec Rehabilitation Institute Research Ethics committee.

4.7.6 Author contributions

All named authors have made a significant and substantial contribution to all aspects of the study. Each of the named authors provided a meaningful contribution to the conception, design, execution and interpretation of the study data in addition to writing, drafting and revising the paper itself. This paper is submitted with the agreement and approval of all authors.

CHAPTER 5

DISCUSSION

The purpose of this thesis was to evaluate the effects of a novel, group-based, neuromuscular training program for the upper extremities for the management of a RC tendinopathy among an active military population. Our intentions were for the results of our pilot RCT to present preliminary data to initiate a discussion regarding the equal effectiveness of a group-supervised approach compared to one-on-one care for common MSK conditions, such as those involving the shoulder complex. Moreover, the purpose of this thesis was also to facilitate the understanding of neuromuscular motor control and proprioception of the shoulder complex for clinicians. Because of the important mobility of the GH joint and the floating nature of the scapula along the thoracic wall, the shoulder complex relies on an astute sense of motor control and proprioception. Our goal was therefore, to also explore the measurement of shoulder proprioception, including the sub-categories of joint position sense and kinesthesia, and to present their associated psychometric properties.

5.0 The pilot RCT

The original hypothesis of our project, specifying both groups demonstrating improvements over time, was confirmed with a statistically significant time effect for both groups with the DASH questionnaire and the WORC Index, from baseline to 12-weeks post-intervention (T_{12}). Furthermore, both groups demonstrated clinically important differences at T_6, by surpassing the minimal clinically important difference (MCID) for both the DASH questionnaire and the WORC Index. Although limited by our sample size, affecting the level of statistical significance of our results, both groups did established strength gains in MVIC for the external rotators and abductor muscles of the injured shoulder over time. Additionally, only the UPC (control) group demonstrated a clinically important decrease in shoulder pain at rest. The UPC group did demonstrated marginally better results in all outcome measures at T_6 and T_{12}, although not statistically significant when compared to the UpEx-NTP (experimental) group. Although, the UPC group demonstrated greater clinically significant improvements compared to the UpEx-NTP group, both groups demonstrated a decrease in pain and functional limitations and an increase in overall shoulder function over time.

5.1 Potential central adaptations with both interventions

One explanation for the fact that we observed positive effects for both interventions over time, could be due to the participants of the UPC group also using strengthening and motor control exercises with unconstrained movements in functional ranges and positions. Such exercises could have provoked positive adaptations to the central nervous system (central sensitization) in both groups. Such active exercises increase muscle activation, optimize proprioceptive feedback from the musculotendinous mechanoreceptors,[47] and could have stimulated central adaptations.[125, 297] Both groups used an active exercise approach among their treatments; the UPC using a combination of hands-on treatments and exercise (one-on-one usual care), and the UpEx-NTP group approach, using active exercises only. This remains a commonality between the two groups, notwithstanding the delivery method of one-on-one with a physiotherapist or in a supervised-group setting. The bottom line being, both groups used active exercises in their management of the RC tendinopathy. It can be hypothesized that both interventions had positive neurophysiological effects on the central nervous system, thus supporting positive changes in pain and function over time for both groups.

There is emerging support to suggest that a RC tendinopathy is associated with changes to both the peripheral and central nervous system,[125, 297, 298] yet this line of scientific investigation remains in its infancy. If there is indeed a neurophysiological component to a RC tendinopathy, it would be interesting to compare the functional outcomes reached between a non-exercises / hands-on approach (ie. manual therapy, modalities as with our UPC group) and an active exercise only approach (as with our UpEx-NTP) among individuals with a RC tendinopathy.

Despite both groups having positive gains over time, the UPC group did demonstrate slightly better results with all outcome measures, at both T_6 and T_{12}. The superior improvements of the UPC group could be due to their stronger adherence to treatment throughout the study. Adherence to treatment has long been identified as important to securing successful outcomes,[296] however, it has also been described as "the most unpredictable, least controllable variable of a medical intervention".[299] The greater functional gains of the UPC group could also be attributed to their one-on-one relationship developed over time with the physiotherapist. A one-on-one treatment environment may further encourage a patient-centric approach, compared to a group setting. A patient-centered physiotherapy approach has been

associated with an increase in patient communication, confidence, knowledge transfer, and treatment satisfaction.[300] To support the applicability of this theory to our results, more research is justified with a military population.

5.2 Improvement to our UpEx-NTP

Each station and chosen exercises of our program were based on clinical experience and the scientific literature. The functional stations were geared towards the athletic inclined military population. The strengths of our program include a novel, group neuromuscular training program specifically designed to address strength, motor (re)learning and proprioceptive deficits associated with a RC tendinopathy. Our program also provided direct supervision by an experienced physiotherapist, adequate space, equipment and infrastructure, and multiple opportunities throughout the week for the participants to attend the structured-group program. The program also offered clear parameters for each station and various modifications for each exercise so that they may be adapted to each participant and their level of pain (3/10 or less throughout the entire program).

Our greatest obstacle was treatment compliance of the participants to the program. Three times a week over a 6-week period proved challenging for the nomadic military population. This challenge has been echoed by a quantitative study by Sandford and colleagues (2017), who reported that time and "needing to fit an extra thing during the day" can be a barrier to exercise.[296] They further suggested that the relationship between the reduction in the impact that the condition is having on a person's life, and the reduction in adherence is intrinsically interlinked.[296] Staying true to this logic, perhaps a supervised-exercise program twice a week with a complimentary home exercise program would afford the participants greater flexibility and control over their schedule, and ultimately increase their adherence to treatment.

Another point of friction of our program was the progression of exercises at each station. Although pain, self-reported participant ability, and feedback from the supervising physiotherapist was used to progress or modify each exercise, a quantitative measure used as a guiding tool to progress the exercises would have been useful. For this reason, we would recommend future studies to use a level of perceived exertion scale, such as the Borg Scale of Perceived Exertion,[301] to provide a quantitative basis for the progression

of each exercise. For example, an exercise may be progressed to a more challenging version when the participant reports a 17 (Very Hard) on the 20-point Borg Scale.

5.3 Our study amongst the scientific literature

Our preliminary results from our pilot RCT lie within the current scientific trends for the management of a shoulder RC tendinopathy. At present, there is support to suggest that a conservative multimodal approach[286] coupled with active exercise is considered to be best practice,[286 135, 138, 141, 145] as reflected by our control group.

A recent systematic review (2015)[156] suggests low- to moderate-quality evidence, for the use of manual therapy among individuals with a RC tendinopathy. This review further states that although manual therapy may decrease pain, it is unclear if it can improve function over time. On the other hand, manual therapy has been theorized to stimulate joint mechanoreceptor activity, thought to block afferent pain signals and ultimately reduce the awareness of pain.[138, 302] In the UPC group, the manual techniques could have optimized the effects of the exercises, by encouraging a decrease in pain of the shoulder complex. This could partially explain the statistically and clinically important improvements in our UPC group that could be due to the hands-on manual therapy techniques applied by the physiotherapists.

Naturally, there are studies to also suggest that exercise therapy is equally as effective as a multiple treatment approach for the management of shoulder pain.[289, 303] In contrast to the support for conservative multimodal care, there are an equal amount of studies to propose that exercise alone, is sufficient for pain reduction and functional gains among this population.[142, 157, 159, 160] There is also emerging support for a structured exercise program for the rehabilitation of a RC tendinopathy.[138, 152, 176, 180, 181] A recent systematic review (2015) by the Ontario Protocol for Traffic Injury Management (OPTIMa), suggests that a progressive shoulder strengthening and stretching program is equally as effective as corticosteroid injection or multimodal care for the management of a shoulder impingement syndrome.[282]

However, this support for a structured exercise program for a RC tendinopathy needs to be critically considered. Some of the studies in favor of a structured exercise program for a RC tendinopathy, did not include a control group for comparison,[97, 176 177] or were unsupervised home based programs.[176, 178, 179]

Furthermore, the evidence for a clinically supervised and structured program for this population, is just as scientifically uncertain. Published studies are currently boasting mixed results, where some studies are reporting greater functional improvements among the exercise group,[169, 172] some suggesting equal results between the exercise and control group,[168, 171, 173, 175, 178, 179] and another favoring better functional results with the control group, reflecting usual physiotherapy care in a clinic.[138]

Although our results may slightly lean away from promoting the use of a group-supervised approach, we acknowledge that further exploration on the effects of such an approach is warranted in order to offer clinicians definitive conclusions.[156, 283, 304]

5.4 The impact of our pilot RCT

To our knowledge, this is the first pilot RCT to investigate the effects of a neuromuscular group program to usual physiotherapy care for the management of a RC tendinopathy among soldiers. It is no surprise that many populations who perform repetitive upper extremity movements, such as manual workers, emergency workers (fire fighters, ambulance attendants, nurses), military members, and athletes, to name a few, are at greater risk for developing shoulder tendinopathy symptoms.[146, 173] It is a biomechanical problem that is deeply rooted in muscular imbalances and motor control deficits of the shoulder complex.[220] Our novel shoulder neuromuscular program directly targets the underlying neuromuscular imbalances associated with this pathology, and suggests a model that promotes patient autonomy, while providing the appropriate level of clinical supervision. Moreover, this is a scientific project that challenges the efficiency and resourcefulness of a one-on-one approach in rehabilitation clinics. It is our hopes that, with further research proving its efficacy, our exercise-based model can be eventually applied to clinics across Canada and can help address the issues involved in access and cost of rehabilitative care.

An interesting area to further explore would be the conceivable impact that a group-supervised program could offer rehabilitation facilities across Canada, in terms of a more resource efficient, and cost effective model for patient care.[182] This also includes a potential decrease in waitlist time for access to care, as well as a more valuable allocation of human resources, such as physiotherapist and physiotherapy assistants. This is not to suggest that all MSK disorders or individuals are suited to a group rehabilitation approach. However, this in the very least offers a potential new avenue for scientific exploration. What MSK disorders are best suited for a supervised-group approach? Are there prognostic indicators,

compliance factors, comorbidities, or social situations that should be identified before participating in a group setting? There is ample room for further study regarding this line of inquiry. Further randomized clinical trials and prospective studies could help evaluate the impact a group-treatment approach could have on patient recovery as well as on the treatment management strategies of rehabilitation clinics. Another avenue that still requires scientific validation is the development and use of shoulder proprioceptive outcome measures for a clinical setting that are psychometrically sound. Valid, reliable, and responsive outcome measures would allow clinicians to confidently assess the effect such group programs could have on motor control and proprioceptive limitations of the shoulder.

5.5 The shoulder proprioception systematic review

An additional objective of this thesis was to proceed with a systematic review for a better understanding as to how shoulder proprioception is being quantified in a laboratory and clinical setting, in order to identify the best shoulder proprioceptive outcome measures that could be employed easily and effectively by clinicians. Conjunctly, in search of a proprioceptive outcome measure for our own pilot RCT, a gap within the scientific literature became evident. The majority of the described protocols identified, involved high-tech and computer-interfaced equipment that would have been unrealistic to use in a clinical setting. Moreover, the outcome measures that were identified as being accessible to clinicians, did not support acceptable levels of validity, reliability, or responsiveness measures to make confident clinical decisions.

The results of our systematic review encourage the preliminary use of passive shoulder protocols that involved assessing shoulder internal or external rotation at 90° of shoulder abduction using an isokinetic dynamometer, such as the Biodex. Although the findings of our systematic review could not be pooled into a meta-analysis, our results can offer a precursory guidance to clinicians for proprioceptive shoulder assessments, as well as to encourage researchers to use such elements in their protocols in order to encourage potential meta-analysis and stronger clinical guidelines.

This is currently in line with attempts to quantify proprioception at other joints.[92, 305-307] A systematic review by Hillier and colleagues (2015) reported that proprioceptive measurements of the lower back, ankle, knee and shoulder, were inadequately missing reported psychometric properties,[239] putting into

question the utility of such proprioceptive protocols for assessing MSK impairements.[239] Indeed, this has been mirrored by other reviews addressing proprioceptive deficits of the lower back,[94] knee[263, 264] and ankle[265] which reported moderate to good psychometric properties at best. This suggests that further experimentation is warranted to establish statistically strong outcome measures that are reproducible and used with various populations and MSK disorders within a clinical setting.

For our systematic review, we chose to investigate joint position sense and kinesthesia, because they are the most employed methods for quantifying shoulder proprioception.[245] It would be interesting to investigate the clinical applicability of the other sub-categories of shoulder proprioception, including but not limited to, sense of vibration, sense of joint velocity, and force-matching tasks. Further study should include the exploration of the associated psychometric properties of these sub-categories, so that clinicians may confidently employ shoulder proprioception protocols or outcome measures that have been psychometrically justified.

5.6 The future is promising

Both the pilot RCT and the systematic review included in this thesis were exploratory in nature and lacked the statistical power to offer clear clinical guidelines at this time. What this thesis does offer, however, is a way forward for future investigative efforts and clear suggestions for prospective research exploring shoulder proprioception and the management of a RC tendinopathy. The following section will outline the lessons learned, recommendations for clinicians, as well as potential areas for further investigation in the near future.

5.6.1 Lessons learned

- Proprioception is a multi-faceted and complex neurological concept which may be difficult to effectively quantify in a clinical setting;
- Scientific studies should consider the reproducibility of their protocols to encourage future use by other researchers, as well as to increase the possibility of combined data for meta-analysis and stronger statistical inferences;

- All parameters of any exercise program (repetitions, series, criteria for progression, rest periods) should be clearly described to encourage other researchers and clinicians to validate/use these exercise programs, making of such initiative a valuable effort and an added value to the management of the conditions targeted by these programs.

5.6.2 Recommendations for clinicians

- To encourage increased compliance to a treatment, implement a brief tele-support (phone call or e-mail) reminder a day or two before a rehabilitation session;[295]
- To facilitate adherence to a group-exercise program, highlight the benefits of the exercises to the patient, incorporating the program into a well-established routine, and implement more intensive monitoring during the program;[296]
- Regarding a group-exercise approach, establish realistic treatment parameters, such as twice a week in-clinic treatments with a complementary home exercise program to potentially increase adherence to treatment;
- Set specific patient goals considered as a minimal requirement to ensure effectiveness of treatment;
- Employ evidence-based and psychometrically robust shoulder proprioceptive protocols in a clinic;
- Although less easily accessible in a clinical setting at the moment, the most reliable method of measuring shoulder proprioception currently includes protocols which use passive protocols with IR / ER at 90° abduction with an isokinetic dynamometer, such as the Biodex.

5.7 Future research

From our preliminary work, we can suggest the following areas for future study that should include:

- Further investigation into the effects of one-on-one usual physiotherapy care compared to a group setting for the management of a RC tendinopathy, within and outside of a military context;
- Further explore the effects of a well-structured neuromuscular training programs for the upper extremities for treating MSK symptoms over time;
- The reproduction of our presented RCT protocol with a larger sample size;

- Explore the concept of central nervous system adaptations (central sensitization) among individuals with a RC tendinopathy. Can this theoretical concept be altered by specific treatments (i.e. no exercises versus a pure active exercise alone approach)?
- The potential economic impact of a group-exercise program on the access to physiotherapy, specifically wait-list time, as well as the allocation of clinic resources (materials, time, personnel);
- Clinically-friendly outcome measures for shoulder proprioception that are valid, reliable, and responsive to change.

There is potential for a structured and supervised, group-exercise program to be a symptomatically effective, and a clinically practical solution for the rehabilitation of a RC tendinopathy. Further investigation with larger sample sizes is needed to support the results of this pilot randomized control trial.

CHAPTER 6

CONCLUSIONS

This thesis grew from a clinical curiosity about motor control and proprioceptive limitations that are associated with a RC tendinopathy; which is currently the leading source of shoulder pain among an adult population. Despite such physical limitations being well established with this shoulder disorder, there is little guidance to offer clinicians in terms of quantifying such deficits, or how they should be rehabilitated through an evidence-based approach. This thesis includes the exploration of the literature through a systematic review, in an attempts to clearly identify the best way psychometrically to quantify shoulder proprioception in a clinical setting. From the results of this review, we can encourage the preliminary use of a shoulder proprioceptive protocol which employs an isokinetic dynamometer, such as the Biodex, for either a passive protocol (JPS) or a detection of movement protocol (kinesthesia), evaluating the movements of internal or external rotation at 90° of shoulder abduction. Such methods support the strongest reliability measures over time and represent the best method for quantifying shoulder proprioceptive deficits in the clinic at this time. Our efforts were further concentrated on comparing usual one-on-one physiotherapy care to a novel, group neuromuscular training program for the upper extremities, to address the functional limitations associated with a RC tendinopathy with active military members. Although our results emerged in the form of a pilot RCT, due to a small sample size, there is still potential to suggest a group approach could be as just effective as one-on-one care for this population. From our preliminary data, both the supervised-group program and usual one-on-one physiotherapy care interventions resulted in statistically significant improvements over time. The one-on-one physiotherapy care group demonstrated clinically important differences with self-reported pain levels at rest. Our findings encourage further investigation, in order to determine the effectiveness of a structured and supervised-group program for the management of a RC tendinopathy as well as other MSK shoulder conditions.

Fundamentally, our research hopes to encourage the exploration of the potential economical argument for the use of supervised-group rehabilitation programs for the management of common MSK conditions, in terms of clinical resources such as materials, time, and personnel. There is potential for a structured and supervised group approach to be a realistic, and financially beneficial solution to the costly health care problem of shoulder pain.

REFERENCES

1. Borsook D. Neurological disease and pain. *Brain.* 2012;135(2):320-344.
2. Boyar A. *Thesis: Shoulder proprioception in male tennis players between ages 14-16.* : The Graduate School Of Social Sciences Of Middle East Technical University. Middle East Technical University; 2006.
3. Sherrington C. *The integrative action of the nervous system*. New York: Scibner's 396 Son; 1906.
4. Li K, & Wu, Y. Clinical evaluation of motion and position sense in the upper extremities of the elderly using motion analysis system. . *Clinical Interventions in Aging.* 2014;9:1123-1131.
5. Clark NC, Roijezon, U., & Treleaven, J. Proprioception in musculoskeletal rehabilitation. Part 2: Clinical assessment and intervention. *Manual Therapy.* 2015;20:378-387.
6. Han J, Waddington, G., Adams, R., Anson, J., & Liu Y. Assessing proprioception: a critical review of methods. *Journal of Sport and Health Science.* 2016;5(1):80-90.
7. Abbas J. *Neuromuscular Control Systems, Models of*. New York: Springer Science & Business Media; 2014.
8. Magill RA. Chapter 1: The Classification of Motor Skills. *Motor Learning and Control: Concepts and Applications.* . 7th Ed. ed. New York: Mc-Graw-Hill; 2004.
9. Risberg MA, Mork, M., Jenssen, H.K., & Holm, I. Design and implementation of a neuromuscular training program following anterior crutiate ligament reconstruction. *JOSPT.* 2001;31(11):620-631.
10. Latash ML, Levin, M.F., Scholz, J.P., & Schöner, G. Motor control theories and their application. *Medicina (Kaunus).* 2010;46(6):382-392.
11. Benjamin M, Kaiser, E., & Milz, S. Struture-function relationships in tendons: a review. *J Anat.* 2008;212(3):211-228.
12. Bass E. Tendinopathy: Why the difference between tendinitis and tendinosis matters. *Int J Ther Massage Bodywork.* 2012;5(1):14-17.
13. Neer CS. 2nd impingement lesions. *Clin Orthop Relat Res.* 1983(173):70-77.
14. Page P. Shoulder muscle imbalance and subacromial impingement syndrome in overhead athletes. *IJSPT.* 2011;6(1):51-58.
15. Shin KM. Partial-thickness rotator cuff tears. *The Korean Journal of Pain.* 2011;24(2):69-73.
16. Luime JJ, Koes, B.W., Hendriksen, I.L., et al. . Prevalence and incidence of shoulder pain in the general population, a systematic review. *Scand J Rheumatol.* 2004;33:73-81.
17. May S. An outcome audit for musculoskeletal patients in primary care. *Physiotherapy theory and practice.* 2003;19(4):189-198.
18. Robb G, Arroll, B., Reid, D., & Goodyear-Smith, F. Summary of an evidence-based guideline on soft tissue shoulder injuries and related disorders -Part 2: Management. *J Prim Health Care.* 2009;1(1):42-49.
19. Canada S. Canadian Community Health Survey: Combined data 2013/2014. Available at: http://www.statcan.gc.ca/daily-quotidien/150624/dq150624b-eng.pdf.
20. Lewis JS. Rotator cuff tendinopathy / subacromial impingement syndrome: is it time for a new method of assessment? *Br J Sport Med.* 2009;43:259-264.
21. Largacha M, Parsons, I.M., Campbell, B., Titelman, R.M., Smith, K.L et al. . Deficits in shoulder function and general health associated with sixteen common shoulder diagnoses: a study of 2674 patients. . *J Shoulder Elbow Surg.* 2006;15(1):30-39.

22. Zakaria D, Robertson, J., MacDermid, J.C., Hartford, K., & Koval J. Estimating the population at risk for Ontario Workplace Safety and Insurance Board-covered injuries or diseases. *Chronic Dis Can.* 2002;23(1):17-21.
23. Roy JS, Desmeules, F., Frémont, P., Dionne, C.E., & MacDermid, J.C. L'évaluation clinique, les traitements et le retour en emploi de travailleurs souffrant d'atteintes de la coiffe des rotators. Blian des connaissances. *Programme REPAR-IRSST Rapport R-885,* 2015.
24. Hébert LJ. Are MSK injuries a hidden threat to the Canadian Armed Forces? *Journal of Military, Veteran, and Family Health.* 2016;2(1).
25. Cameron KL, & Owens, B.D. The burden and management of sports-related musculoskeletal injuries and conditions within the US military. *Clin Sports Med.* 2014;33(4):573-589.
26. Hsiao MS, Cameron, K.L., Tucker, C.L., Benigni, M., Blaine, T.A., & Owens, B.D. Shoulder impingement in the United States military. . *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons.* 2015;24(9):1486-1492.
27. Murray M, Lange, B., Nornberg, B.R., Sogaard, K., and Slogaard, G. Specific exercise training for reducing neck and shoulder pain among military helicopter pilots and crew members: a randomized controlled trial protocol. *BMC Musculoskeletal Disorders.* 2015;19(16):198.
28. Dumont GD, Golijanin, P., Provencher, M.T. Shoulder instability in the military. *Clin Sports Med.* 2014;33(4):707-720.
29. Waterman BR, Burns, T.C., McCriskin, B., Kilcoyne, K., Cameron, K.L. et al. Outcomes after bankart repair in a military population: predictors for surgical revision and long-term disability. *Arthroscopy.* 2014;30(2):172-177.
30. Yang AJ, & Jain, N.B. Shoulder. In: Yong RJ, Nguyen, M., Nelson, E., & Urman, R.D., ed. *Pain medicine: An essential review.* Vol Part II. Switzerland: Springer International Publishing.; 2017.
31. Matthes G, Horvath, V., Seifert, J., Ptok, H., Stengel, D. et al. Oldie but goldie: Bristow-Latarjet procedure for anterior shoulder instability. *J Ortho Surg.* 2007;15(1):4-8.
32. Jaggi A, & Lambert, S. Rehabilitation for shoulder instability. *Br J Sport Med.* 2010;44:333-340.
33. Schenkman M, & Rugo de Cartaya, V. Kinesiology of the shoulder complex. *J Orthop Sports Phys Ther.* 1987;3:438-450.
34. Gates DH, Walters, L.S., Cowley, J., Wilken, J.S., & Resnik, L. Range of motion requirements for upper-limb activites of daily living. *American Journal of Occupational Therapy.* 2017;70(1):7001350010p7001350011–7001350010p7001350010.
35. Roe Y, Lundgaard Soberg, H., 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 Musculoskeletal Disorders.* 2013;14(73):1-12.
36. Bennell K CS, Wee E, Green S, Harris A, Forbes A, et al. . Efficacy and cost-effectiveness of a physiotherapy program for chronic rotator cuff pathology: a protocol for a randomised, double-blind, placebo-controlled trial. . *BMC Musculoskeletal Disorders.* 2007;8(86).
37. Meislin RJ, Sperling, J.W., & Stitik, T.P. Persistent shoulder pain: epidemiology, pathophysiology, and diagnosis. *Am J Orthop.* 2005;34(12 (Suppl.)):5-9.
38. Littlewood C. Contractile dysfunction of the shoulder(rotator cuff tendinopathy): an overview. *J Man Manip Ther.* 2012;20(4):209-213.
39. Kuijpers T, van Tulder, M., van der Heijden, G., Bouter, L., van der Windt, D. Cost of shoulder pain in primary care consulters: a prospective cohort study in the Netherlands. . *BMC Musculoskeletal Disorders.* 2006;7(83).

40. Lebeau M, Duguay, P., Boucher, A. . *Les coûts des lésions professionnelles au Québec 2005-2007.* Montréal, Quebec: Institut de recherche Robert-Sauvé en santé et en sécurité du travail.; 2013.
41. Hébert LJ. *The use of a systematic process to reduce MSK injuries in the CF: comparisons of MSK injury profiles between the three CF environments, bases with different training requirements, and MOSIDs.* Valcartier, QC.: Canadian Armed Forces.; Mar 2005. 2005.
42. Hébert LJ, & Rowe, P. The lessons learned from the Canadian Forces physiotherapy experience during the peacekeeping operations in Bosnia. *Mil Med.* 2007;172(8):829-834.
43. Panel P. Philadelphia Panel evidence-based clinical practice guidelines on selected rehabilitation interventions for shoulder pain. *Phys Ther.* 2001;81(10):1719-1730.
44. Via AG, De Cupis, M., Spoliti, M., & Oliva, F. Clinical and biological aspects of rotator cuff tears. *Muscles Ligaments Tendons J.* 2013;3(2):70-79.
45. Factor D, & Dale, B. Current concepts of rotator cuff tendinopathy. *Int J Sports Phys Ther.* 2014;9(2):274-288.
46. Littlewood C, May, S., & Walters, S. Epidemiology of rotator cuff tendinopathy: a systematic review. *Shoulder & elbow.* 2013;5(4):256-265.
47. Suprak DN, Osternig, L.R., van Donkelaar, P., & Karduna, A.R. Shoulder joint position sense improves with elevation angle in a novel, unconstrained task. . *Journal of Orthopedic Research.* 2006;24(3):559-569.
48. Bushnell BD, Creighton, R.A., & Herring, M.M. Bony instability of the shoulder. *J Arthroscopy and Related Surgery.* 2008;24(9):1061-1073.
49. Anderson BC. *Office orthopedics for primary care: Diagnosis.* Philadelphia; 2005.
50. Neer CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Jt Surg.* 1972;54:41-50.
51. Põldoja E, Rahu, M., Kask, M., Weyers, I., & Kolts, I. Blood supply of the subacromial bursa and rotator cuff tendons on the bursal side. *Knee Surg Sports Traumatol Arthrosc.* 2016.
52. Tillmann B, & Gehrke, T. Funktionelle anatomie des subakromialen raums. *Arthroskopie.* 1995;8:209-217.
53. Morgan R, & Herrington, L. The effect of tackling on shoulder joint positioning sense in semi-professional rugby players. *Physical Therapy Sport.* 2014;15:176-180.
54. Lephart SM, Pincivero, D.M., Giraldo, J.L., & Fu, F.H. The role of proprioception in the management and rehabilitation of athletic injuries. *Am J Sports Med.* 1997;25(1):130-137.
55. Kennedy JC, Alexander, I.J., & Hayes, K.C. . Nerve supply of the human knee and its functional importance. *Am J Sports Med.* 1982.;10:329-335.
56. Edouard P, Gasq, D., Calmels, P., Ducrot, S., Degache, F. Shoulder sensorimotor control assessment by force platform: feasibility and reliability. *Clin Physio Funct Imaging.* 2012;32(5):409-413.
57. Witherspoon JW, Smirnova, I.V., & McIff, T.E. Neuroanatomical distribution of mechanoreceptors in the human cadaveric shoulder capsule and labrum. *J Anat.* 2014;225:337-345.
58. Kandel E, Schwartz, J., & Jessell, T. *Principles of Neuroscience.* New York.: McGraw-Hill.; 2000.
59. Wamer JJ, Lephart, S., & Fu, F.H. Role of proprioception in pathoetiology of shoulder instability. *Clin Orthop Relat Res.* 1996;330:35.39.
60. Janwantanakul P, Magarey, M.E., Jones, M.A., & Dansie, B.R. Variation in shoulder position sense at mid and extreme range of motion. *Arch Phys Med Rehabil.* 2001;82:840-845.

61. Brukner P, & Khan, K. et al. Chapter 17: Shoudler Pain. In: Pike C, ed. *Clinical Sports Medicine.* 3rd Ed. ed. Autralia: McGraw-Hill Autralia Pty Ltd.; 2010: 244-259.
62. Jobe C. Evaluation of impingement syndromes in the overhead throwing athlete. *J Athl Train.* 2000;35(3):293.
63. Vafadar AK, Côté, J.N., & Archambault, P.S. . Inter-rater and Intra-rater reliability and validity of three measurement methods for shoulder position sense. *Journal of Sport Rehabilitation Technical Report.* 2015(19):2014-0309.
64. Craig J, et al. *Chapter 12: Biomechanics of the shoulder.* Philadelphia: Lippincott Williams & Wilkins; 2001.
65. Dal Maso F, Raison, M., Lundberg, A, Arndt, A., Allard, P., Begon, M. Glenohumeral translation during range of motion movements, activities of daily living, and sports activities in healthy participants. *Clin Biomech (Bristol Avon).* 2015;30(9):1002-1007.
66. Milgrom C, Schaffer, M., Gilbert, S., & van Holsbeeck, M. Rotator cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Jt Surg.* 1995;77:296-298.
67. Jam B. New paradigms in rotator cuff retraining. *APTEI Report.* 2004.
68. David G, Jones, M., & Magarey, M. Rotator cuff muscle performances during gleno-humeral joint rotations: An isokinetic, electromyographic and ultrasonographic study. Paper presented at: Manipulative Physiotherapists Association of Australia Conference Proceedings., 1997; Melborne, Australia.
69. Sahrmann SA. *Diagnosis and treatment of movement impairement syndromes.* St. Louis.; 2002.
70. Struyf F, Nijs, J., Baeyens, J.P., Mottram, S., Meeusen, R. Scapular positioning and movement in unimpaired shoulders, shoulder impingement syndrome, and glenohumeral instability. *Scandinavian Journal of Medicine and Science in Sports.* 2011;20(3):352-358.
71. Dayanidhi S, Orlin, M., Kozin, S., Duff, S., Karduna, A. Scapular kinematics during humeral elevation in adults and children. *Clin Biomech (Bristol Avon).* 2005;20(6):600-606.
72. Wu G, van der Helm, F.C., Veeger, H.E. et al. ISB recommendation on definitions of joint coordinate systems of various joints for the reporting of human joint motion - Part II: shoulder, elbow, wrist and hand. *J Biomech.* 2005;38:981-992.
73. Ludewig PM, & Braman, J.P. Shoulder impingement: biomechanical considerations in rehabilitation. *Man Ther.* 2011;16(1):33-39.
74. Zhao KD, Van Straaten, M.G., Cloud, B.A., Morrow, M.M., An, K-N., & Ludewig, P.M. Scapulothoracic and glenohumeral kinematics during daily tasks in users of manual wheelchairs. *Frontiers in Bioengineering and Biotechnology.* 2015;3:183-193.
75. Paine RM, & Voight, M.L. The role of the scapula. *J Orthop Sports Phys Ther.* 1993;18:386-391.
76. Voight ML, & Thomson, B.C. The role of the scapula in the rehabilitation of shoulder injuries. *J Athl Train.* 2000;35(5):364-372.
77. Paine R, & Voight, M.L. The role of the scapula. *Int J Sports Phys Ther.* 2013;8(5):618-629.
78. Ludewig P. M. CTM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. *Phys Ther.* 2000;80:276-291.
79. Lukasiewicz A. C. MP, Michener L., Pratt N., & Sennett B. . Comparison of 3-dimensional scapular position and orientation between subjects with and without shoulder impingement. *J Orthop Sports Phys Ther.* 1999;29:574-583.
80. Ludewig PM, & Reynolds, J.F. . The association of scapular kinematics and glenohumeral joint pathologies. *J Orthop Sports Phys Ther.* 2009;39(2):90-104.

81. Gombera MM, & Sekiya, J.K. Rotator cuff tear and glenohumeral instability: a systematic review. *Clin Orthop Relat Res.* 2014;472(8):2448-2456.
82. Soslowsky LJ, Thomopoulos, S., Esmail, A. et al. . Rotator cuff tendinosis in an animal model: Role of extrinsic and overuse factors. *Annals of Biomedical Engineering.* 2002;30(8):1057–1063.
83. Veeger HE, & van der Helm, F.C. Shoulder function: the perfect compromise between mobility and stability. *J Biomech.* 2007;40(10):2119-2129.
84. O'Sullivan SB, & Schmitz, T. J. *Physical Rehabilitation: Chapter 13 Motor Control.* Philadelphia: F.A. Davis Company; 2007.
85. Serrien D, & Wiesendanger, M. Temporal control of a bimanual task in patients with cerebellar dysfunction. *Neuropsychologia.* 2000;38(5):558-565.
86. Cordo P, Carlton, L., Bevan, L., Carlton, M., & Kerr, G.K. Proprioceptive coordination of movement sequences; role of velocity and position information. *J Neurophys.* 1994;71(5):1848-1861.
87. Bard C, Fleury, M., Teasdale, N., Paillard, J., & Nougier, V. Contribution of proprioception for calibrating and updating the motor space. *Can J Physiol Pharmacol.* 1995;73(2):246-254.
88. Marini F, Squeri, V., Morasso, P., Campus, C., Konczak, J., & Masia, L. Robot-aided developmental assessment of wrist proprioception in children. *J Neuroeng Rehabil.* 2017;9(14):3.
89. Sainburg RL, Ghilardi, M.F., Poizner, H., & Ghez, C. Control of limb dynamics in normal subjects and patients without proprioception. *J Neurophys.* 1995;73(2):820-835.
90. Contemori S, Biscarini, A. Shoulder position sense in volleyball players with infraspinatus atrophy secondary to suprascapular nerve neuropathy. *Scandinavian journal of medicine & science in sports.* 2017.
91. Lephart SM, Warner, J.J.P., Borsa, P.A., & Fu, F.H. Proprioception of the shoulder joint in healthy, unstable, and surgically repaired shoulders. *J Shoulder Elbow Surg.* 1994;3(6):371-381.
92. Al-Othman AA. Clinical measurement of proprioceptive function after anterior cruciate ligament reconstruction. *Saudi medical journal.* Feb 2004;25(2):195-197.
93. Bayramoglu M, Toprak R, Sozay S. Effects of osteoarthritis and fatigue on proprioception of the knee joint. *Arch Phys Med Rehabil.* Mar 2007;88(3):346-350.
94. Tong MH, Mousavi, S.J., Kiers, H., Ferreira, P., Refsauge, K., & van Dieën, J. . Is there a relationship between lumbar proprioception and low back pain? A systematic review with meta-analysis. *Archives of physical medicine and rehabilitation.* 2016;98(1):120-136.
95. Fyrh C, Gustavsson, L., Wassinger, C., & Sole, G. The effect of shoulder injury on kinesthesia: A systematic review and meta-analysis. *Manual Therapy.* 2015(20):28-37.
96. Marzetti E, Rabini, A., Piccinini, G., Piazzini, D.B., Vulpiani, M.C., Vetrano, M., et al. . Neurocognitive therapeutic exercise improves pain and function in patients with shoulder impingement syndrome: a single-blind randomized controlled clinical trial. . *Eur J Phys Rehabil* 2014(50):255-264.
97. Roy JS, Moffet, H., Hébert, L.J., Lirette, R. Effect of motor control and strengthening exercises on shoulder function in persons with impingement syndrome: A single-subject study design. *Man Ther.* 2009;14(2):180-188.
98. Worsley P, Warner, M., Mottram, S., Gadola, S., Veeger, H. et al. . Motor control retraining exercises for shoulder impingement: effects on function, muscle activation and biomechanical

in young adults *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]*. 2013;22(4):e11-e19.
99. Anderson VBW, E. . Impaired joint proprioception in higher shoulder elevations in chronic rotator cuff pathology. . *Arch Phys Med Rehabil* 2011;92:1146-1152.
100. Sahin E, Dilek, B., Baydar, M., Gundogdu, M., Ergin, B. et al. Shoulder proprioception in patients with subacromial impingement syndrome. *J Back Musculoskeletel Rehabil.* 27 Mar 2016. 2016.
101. Chard MD, Halzleman, R., Hlazleman, B.L., King, R.H., & Reiss, B.B. Shoulder disorders in the elderly: a community survey. *Arthritis Rheum.* 1991;34(6):766-769.
102. van der Windt DA, Koes, B.W., de Jong, B.A., & Bouter, L.M. Shoulder disorders in general practice: incidence, patient characteristics, and management. *Ann Rheum Dis.* 1995;54(12):959-964.
103. Arcuni SE. Rotator cuff pathology and subacromial impingement. *Nurse Pract.* 2000;25(5):58-66.
104. Lewis JS, McCreesh, K., Roy, J.S., & Ginn, K. Rotator cuff tendinopathy: Navigating the diagnosis - management conundrum. *Journal of Orthopaedic & Sports Physical Therapy.* 2015;45(11):923-937.
105. Beirer M, Imhoff, A.B., & Braun, S. Impingement syndromes of the shoulder. *Orthopade.* 2017;46(4):373-386.
106. Williams G. Management of rotator cuff and impingement injuries in the athlete. *J Athl Train.* 2000;35(3):300.
107. Andres BM, & Murrell, G.A.C. Treatment of tendinopathy: What works, what does not, and what is on the horizon. *Clin Orthop Relat Res.* 2008;466(7):1539-1554.
108. Brukner P, & Khan, K. et al. . Chapter 2: Sports Injuries. In: Pike C, ed. *Clinical sports medicine.* 3rd ed. ed. Australia.: McGraw-Hill Australia Pty Ltd.; 2010: 22-23.
109. Seitz AL, McClure, P.W., Finucane, S., & Boardman, N.D. Mechanisms of rotator cuff tendinopathy: instrinsic, extrinsic, or both? . *Clin Biomech.* 2011;26(1):1-12.
110. Khan Y, Nagy, M.T., Malal, J., & Waseem, M. The painful shoulder: shoulder impingement syndrome. *Open Orthop J.* 2013;6(7):347-351.
111. Andarawis-Puri N, Flatow, E.L., & Soslowsky, L.J. Tendon Basic Science, Development, Repair, Regeneration, and Healing. *J Orthop Res.* 2015;33(6):780-784.
112. Mistry A, & Cambell, R. S.D. Microinstability and internal impingement of the shoulder. *Semin Musculoskeletal Radiol.* 2015(19):277-283.
113. Muraki T, Yamamoto, N., Sperling, J.W., Steinmann, S.P., Cofield, R.H., & An, K.N. The effect of scapular position on subacromial contact behavior: a cadaver study. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]*. 2017;26(5):861-869.
114. Ludewig PM, & Cook, T.M. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. *Phys Ther.* 2000;80(3):276-291.
115. Borstard JD, & Ludewig, P.M. . Comparison of scapular kinematics between elevation and lowering of the arm in the scapular plan. *Clin Biomech (Bristol Avon).* 2002;17(9-10):560-569.
116. McClure PW ML, Karduna AR. . Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome. *Phys Ther.* 2006;86(8):1075-1090.
117. Reddy AS MK, Pink MM, Jobe FW. Electromyographic analysis of the deltoid and rotator cuff muscles in persons with subacromial impingement. *J Shoulder Elbow Surg.* 2001;9(6):519-523.

118. Wadsworth DJ, & Bullock-Saxton, J.E. Recruitment patterns of the scapular rotator muscles in freestyle swimmers with subacromial impingement. *Int J Sports Med.* 1997;118(8):918-624.
119. Hébert LJ, Moffet, H., McFayden, B.J., & Dionne, C. Scapular behaviour in shoulder impingement syndrome. *Archives of Physical Medicine and Rehabilitation.* 2002;83(1):60-69.
120. Cordasco F. Understanding multidirectional instability of the shoulder. *J Athl Train.* 2000;35(3):278-300.
121. Yanai T. Shoulder impingement in front-crawl swimming: I. A method to identify impingement. *Med Sci Sports Exerc.* 2000;32(1):21.
122. Gwilym SE, Oag, H.C., Tracey, I., & Carr, A.J. Evidence that central sensitisation is present in patients with shouder impingement syndrome and influences the outcome after surgery. *J Bone Jt Surg Br.* 2011;93:498-502.
123. Coronado RA, Simon, C.B., Valencia, C., & George, S.Z. Experimental pain responses support peripheral and central sensitization in patients with unilateral shoulder pain. *Clin J Pain.* 2014;30:143-151.
124. Paul TM, Soo Hoo, J., Chae, J., Wilson, R.D. Central hypersensitivity in patients with subacromial impingement syndrome. . *Arch Phys Med Rehabil.* 2012;93(12):2206-2209.
125. Ngomo S, Mercier, C., Bouyer, L.J., Savoie, A., & Roy,J.S. Alterations in central motor representation increase over time in individuals with rotator cuff tendinopathy. *Clin Neurophysiol.* 2015;126(2):365-371.
126. Godman GP, Schoenfied, A.J., Owens, B.D., Dutton, J.R., Burks, R., & Belmont, P.J. Non-emergent orthopaedic injuries sustained by soldiers in Operation Iraqi Freedom. *J Bone Jt Surg.* 2012;94(8):728-735.
127. Teyhen DS, Rhon, D.I., Butler, R.J., Shaffer, S.W., Goffar, S.L. et al. Association of physical inactivity, weight, smoking, and prior injury on physical performance in a military setting. *J Athl Train.* 2016;51(11):866-875. .
128. Jones BH, Canham-Chervak, M., Canada, S. et al. Medical surveillance of injuries in the US Military: descriptive epidemiology and recommendations for improvement. . *Am J Prev Med.* 2010;38((1 Suppl)):S42-60.
129. Ruscio BA, Jones, B.H., Bullock, S.H., et al. A process to identify military injuries prevention priorities based on injury type and limited duty days. *Am J Prev Med.* 2010;38((1 Suppl)):S19-33.
130. Group CFHS. *Surgeon General's Report: Ottawa.* 2010.
131. Group CFHS. *Surgeon General's Report* 2014.
132. Fang L, Payne, E., & Vallée M.N. *Injury surveillance: mind the gaps. Report for 5 Field Ambulance chain of command meeting.* Valcariter, QC.: Canadian Armed Forces Health Services Group.; Mar 2013. 2013.
133. Camarinos J, & Marinko, L. Effectiveness of manual physical therapy for painful shoulder conditions: A systematic review. *J Man Manip Ther.* 2009;17(4):206-215.
134. Abrisham SMJ, Kermani-Alghoraishi, M., Ghahramani, R., et al. Additive effects of low-level laser therapy with exercise on subacromial syndrome: a randomised, double-blind, controlled trial. . *Rheumatol.* 2011;30:1341-1346.
135. Page MJ, Green, S., Mrocki, M.A., Surace, S.J., Deitch, J., McBain, B., Lyttle, N., & Buchbinder, R. Electrotherapy modalities for rotator cuff disease. *Cochrane Database Syst Rev.* 2016;10(6):CD012225.
136. Ingber RS. Shoulder impingement in tennis/racquetball players treated with subscapularis myofascial treatments. *Arch Phys Med Rehabil.* 2000;81(5):679-682.

137. Senbursa G, Baltaci, G., & Atay, A. Comparison of conservative treatment with and without manual physical therapy for patients with shoulder impingement syndrome: a prospective, randomized clinical trial. *Knee Surg Sports Traumatol Arthrosc.* 2007;15:915-921.
138. Bang MD, & Deyle, G.D. Comparison of supervised exercise with and without manual physical therapy for patients with shoulder impingement syndrome. *J Orthop Sports Phys Ther.* 2000;30:126-137.
139. Conroy DE, & Hayes. K.W. The effect of joint mobilization as a component of comprehensive treatment for primary shoulder impingement syndrome. *J Orthop Sports Phys Ther.* 1998;28(3-14.).
140. Vas J, Ortega, C., Olmo, V., Perez-Fernandez, F., & Hernandez, L. Single-point acupuncture and physiotherapy for the treatment of painful shoulder: a multicentre randomized controlled trial. *Rheumatol (Oxford).* 2008;47(6):887-893.
141. Dong W, Goost, H., Lin, X.B., Burger, C., Paul, C., Wang, Z.L., Zhang, T.Y., Jiang, Z.C., Welle, K., & Kabir, K. Treatments for shoulder impingement syndrome: a PRISMA systematic review and network meta-analysis. *Medicine (Baltimore).* 2015;94(10):e510.
142. Holmgren T, Hallgren, H.B., Oberg, B., Adolfsson, L., & Johansson, K. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study. *Br J Sport Med.* 2014;48(19):1456-1457.
143. Başkurt Z, Başkurt, F., Gelecek, N., & Özkan, M.H. The effectiveness of scapular stabilization exercise in the patients with subacromial impingement syndrome. *J Back Musculoskeletel Rehabil.* 2011;24(3):173-179.
144. Struyf F, Nijs, J., Mollekens, S., Jeurissen, I., Truijen, S., Mottram, S., & Meeusen, R. Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial. *Clin Rheumatol.* 2013;32(1):73-85.
145. Page MJ, Green, S., McBain, B., Surace, S.J, Deitch, J., Lyttle, N., Mrocki, M.A., & Buchbinder, R. Manual therapy and exercise for rotator cuff disease. *Cochrane Database Syst Rev.* 2016;10(6):CD012224.
146. Desmeules F, Boudreault, J., Dionne, C.E., Frémont, P., Lowry, V., MacDermid, J.C., & Roy, J.S. Efficacy of exercise therapy in workers with rotator cuff tendinopathy: a systematic review. *J Occup Health.* 2016;30(58):389-403.
147. Green S, Buchbinder, R., Hetrick, S. Physiotherapy intervention for shoulder pain. *Cochrane Database Syst Rev.* 2003;2.
148. Green S, Buchbinder, R., & Hetrick, S. Acupuncture for shoulder pain. *Cochrane Database Syst Rev.* 2005;18(2):CD005319.
149. Haik MN, Alburquerque-Sendin, F., Moreira, R.F.C., Pires, E.D., & Camargo, P.R. Effectiveness of physical therapy treatment of clearly defined subacromial pain: a systematic review of randomized controlled trials. *Br J Sport Med.* 2016;50:1124-1134.
150. Desmeules F, Boudreault, J., Roy, J.S., Dionne, C.E., Frémont, P., & MacDermid, J.C. The efficacy of therapeutic ultrasound for rotator cuff tendinopathy: A systematic review and meta-analysis. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine.* 2015;16(3):276-284.
151. Desmeules F, Boudreault, J., Roy, J.S., Dionne, C.E., Frémont, P., & MacDermid, J.C. Efficacy of transcutaneous electrical nerve stimulation for rotator cuff tendinopathy: a systematic review. *Physiotherapy.* 2016;102(1):41-49.

152. Hibberd EE, Oyama, S., Spang, J.T., Prentice, W., & Myers, J.B. Effect of a 6-week strengthening program on shoulder and scapular stabilizer strength and scapular kinematics in division I collegiate swimmers. *Journal of sport rehabilitation.* 2012;21:253-265.
153. Ellenbecker TSC, A. Rehabilitation of shoulder impingement syndrome and rotator cuff injuries: an evidence-based review. *Br J Sport Med.* 2010;44(5):319-327.
154. AAOMPT. American Academy of Orthopaedic Manual Physical Therapists: Educational Standards in Orthopaedic Manual Physical Therapy. Available at: http://aaompt.org/aaompt_data/documents/standards.pdf?hkey=c62fe7d0-5b49-45d6-9b08-6e874ace4944.
155. IFOMPT. The International Federation of Orthopaedic Manipulative Physical Therapists: Standards Document Definitive 2016. Available at: http://www.ifompt.org/STANDARD+COMPLIANCE++TRAINING/Standards+Document.html.
156. Desjardins-Charbonneau A, Roy JS, Dionne CE, Fremont P, MacDermid JC, Desmeules F. The efficacy of manual therapy for rotator cuff tendinopathy: a systematic review and meta-analysis. *J Orthop Sports Phys Ther.* May 2015;45(5):330-350.
157. Littlewood C, May, S., & Walters, S. A Review of Systematic Reviews of the Effectiveness of Conservative Interventions for Rotator Cuff Tendinopathy. *Shoulder & elbow.* 2013;5(3):1-17.
158. Holmgren T, Björnsson Hallgren, H., Öberg, B., Adolfsson, L., & Johansson, K. . Effect of specific exercise strategy on need for surgery on patients with subacromial impingement syndrome: randomised controlled study. *Br J Sport Med.* 2012;48(19):1456-1457.
159. Hanratty CE, McVeigh, J.G., Kerr, D.P., Basford, J.R., Finch, M.B., Pendleton, A., & Sim, J. The effectiveness of physiotherapy exercises in subacromial impingement syndrome: a systematic review and meta-analysis. *Semin Arthritis Rheum.* 2012;42(3):297-316.
160. Littlewood C, Ashton, J., Chance-Larsen, K., May, S., Sturrock, B. Exercise for rotator cuff tendinopathy: a systematic review. *Physiotherapy.* 2012;98(2):101-109.
161. Olney SJ, Nymark, J., Brouwer, B., Culham, E., Day, A., et al. A Randomized Controlled Trial of Supervised Versus Unsupervised Exercise Programs for Ambulatory Stroke Survivors. *Stroke.* 2006;37:476-481.
162. Patterson RB, Pinto, D., Marcus, B., Colucci, A., Braun, T., & Roberts, M. Value of supervised exercise program for the therapy of arterial claudication. *Journal of Vascular Surgery.* 1997;25(2):312-319.
163. Pandey A, Banerjee, S., Ngo, C., Mody, P., Marso, S.P. et al. Comparative Efficacy of Endovascular Revascularization Versus Supervised Exercise Training in Patients With Intermittent Claudication: Meta-Analysis of Randomized Controlled Trials. *JACC Carduivasc Interv.* 2017;10(7):712-724.
164. Savage P, Ricci, M.A., Lynn, M., Gardner, A., Knight, S., Brochu, M., & Ades, P. Effects of Home Versus Supervised Exercise for Patients With Intermittent Claudication. *J Cardiopulm Rehab.* 2001;21(3):152-157.
165. Fokkenrood HJ, Bendermacher, B.L., Lauret, G.J., Willigendael, E.M., Prins, M.H., & Teijink, J.A. Supervised exercise therapy versus non-supervised exercise therapy for intermittent claudication. *Cochrane Database Syst Rev.* 2013;23(8):CD005263.
166. Donat H, & Ozcan, A. Comparison of the effectiveness of two programmes on older adults at risk of falling: unsupervised home exercise and supervised group exercise. *Clinical rehabilitation.* 2007;21(3):273-283.

167. Youssef EF, & Shanb, A.A. Supervised versus home exercise training programs on functional balance in older subjects. *Malays J Med Sci.* 2016;23(6):83-93.
168. Deyle GD, Allison, S.C., Matekel, R.L., Ryder, M.G., Stang, J.M., et al. Physical Therapy Treatment Effectiveness for Osteoarthritis of the Knee: A Randomized Comparison of Supervised Clinical Exercise and Manual Therapy Procedures Versus a Home Exercise Program. *Phys Ther.* 2005;85(12):1301-1317.
169. Fransen M, Margiotta, E., Crosbie, J., & Edmonds, J. A revised group exercise program for osteoarthritis of the knee. *Physiother Res Int.* 1997;2(1):30-41.
170. Krauss I, Mueller G., Haupt, G., Steinhilber B., Janssen, P. et al. . Effectiveness and efficiency of an 11-week exercise intervention for patients with hip or knee osteoarthritis: a protocol for a controlled study in the context of health services research. *BMC Public Health.* 2016;16:367.
171. Tiffreau V, Mulleman, D., Coudeyre, E., Lefevre-Colau, M.M., Revel, M., & Rannou, F. The value of individual or collective group exercise programs for knee or hip osteoarthritis. Elaboration of French clinical practice guidelines. *Annales de réadaptation et de médecine physique.* 2007;50:741-746.
172. Analay Y, Ozcan, E., Karan, A., Diracoglu, D., Aydin, R.. The effectiveness of intensive group exercise on patients with ankylosing spondylitis. *Clinical rehabilitation.* 2003;17(6):631-636.
173. Caputo GM, Di Bari, M., & Orellana, N. Group-based exercise at workplace: short-term effects of neck and shoulder resistance training in video display unit workers with work-related chronic neck pain-a pilot randomized trial. *Clin Rheumatol.* 2017.
174. Gutiérrez-Espinoza H, Rubio-Oyarzún, D., Olguín-Huerta, C., Gutiérrez-Monclus, R., Pinto-Concha, S., & Gana-Hervias, G. Supervised physical therapy vs home exercise program for patients with distal radius fracture: A single-blind randomized clinical study. *J Hand Ther.* 2017.
175. Büker N, Kitiş, A., Akkaya, S., & Akkaya, N. Comparison of the results of supervised physiotherapy program and home-based exercise program in patients treated with arthroscopic-assisted mini-open rotator cuff repair. *Eklem Hastalik Cerrahisi.* 2011;22(3):134-139.
176. McClure PW, Bialker, J., Neff, N., Williams, G., & Karduna, A. Shoulder function and 3-dimensional kinematics in people with shoulder impingement syndrome before and after a 6-week exercise program. *Phys Ther.* 2004;84(9):832-848.
177. De Mey K, Danneels, L., Cagnie, B., & Cools, A.M. Scapular muscle rehabilitation exercises in overhead althletes with impingement symptoms: effect of a 6-week training program on muscle recruitement and functional outcome. *Am J Sports Med.* 2012;40(8):1906-1915.
178. Granviken F, & Vasseljen, O. Home exercises and supervised exercises are similarly effective for people with subacromial impingement: a randomized trial. *J Physiol.* 2015;61(3):135-141.
179. Heron SR, Woby, S.R., & Thompson, D.P. Comparison of three types of exercise in the treatment of rotator cuff tendinopathy / impingement syndrome: a randomized control trial. *Physiotherapy.* 2016;S0031-9406(16):30059-30051.
180. Dilek B, Gulbahar, S., Gundogdu, M., Ergin, B., Manisali, M., Ozkan, M., & Akalin, E. Efficacy of Proprioceptive Exercises in Patients with Subacromial Impingement Syndrome: A Single-Blinded Randomized Controlled Study. *American Journal of Physical Medicine & Rehabilitation.* 2016;95(3):169-182.
181. Savoie A, Mercier, C., Desmeules, F., Frémont, P., & Roy, J.S. Effects of a movement training oriented rehabilitation program on symptoms, functional limitations and acromiohumeral distance in individuals with subacromial pain syndrome. *Man Ther.* 2015;20(5):703-708.

182. Carr JL, Klaber Moffett, J.A., Howarth, E., Richmond, S.J., Torgerson, D.J., Jackson, D.A., & Metcalfe, C.J. A randomized trial comparing a group exercise programme for back pain patients with individual physiotherapy in a severely deprived area. *Disabil Rehabil.* 2005;27(16):929-937.
183. Raymond MJ, Burge, A.T., Soh, S.E., Jeffs, K.J., Winter, A., & Holland, A.E. Experiences of older adults in a group physiotherapy program at a rehabilitation hospital: A qualitative study. *J Hosp Med.* 2016;11(5):358-362.
184. Critchley DJ, Ratcliffe, J., Noonan, S., Jones, R.H., Hurley, M.V. Effectiveness and cost-effectiveness of three types of physiotherapy used to reduce chronic low back pain disability: a pragmatic randomized trial with economic evaluation. *Spine (Phila Pa 1976).* 2007;32(14):1474-1481.
185. Passalent LA, Landry M.D., & Cott, C.A. Exploring wait list prioritization and management strategies for publicly funded ambulatory rehabilitation services in ontario, Canada: Further evidence of barriers to access for people with chronic disease. *Healthcare Policy.* 2010;5(4):e139-e156.
186. Bandholm T, Rasmussen, L., Aagaard, P., Jensen, B.R., & Diederichsen, L. Force steadiness, muscle activity, and maximal muscle strength in subjects with subacromial impingement syndrome. *Muscle Nerve.* 2006;34(5):631-639.
187. Cools AM, Johansson, F.R., Borms, D., & Maenhout, A. Prevention of shoulder injuries in overhead athletes: a science-based approach. *BJPT.* 2015;96(2):298-306.
188. De Mey K, Danneels, L., Cagnie, B., & Cools, A.M. . Scapular muscle rehabilitation exercises in overhead athletes with impingement symptoms: effect of a 6-week training program on muscle recruitment and functional outcome. *Am J Sports Med.* 2012;40(8):1906-1915.
189. Magarey ME, & Jones, M.A. Dynamic evaluation and early management of altered motor control around the shoulder complex. *Man Ther.* 2003;8(4):195-206.
190. Escamilla RF, Yamashiro, K., Paulos, L., & Andrews, J.R. Shoulder muscle activity and function in common shoulder rehabilitation exercises. *Sports Med.* 2009;39(8):663-685.
191. Torres RJ, Pirauá, A.L., Nacimento, V.Y., Dos Santos, P.S., Beltrão, N.B., de Oliveira V.M., Pitangui, A.C., & de Araújo, R.C. Shoulder muscle activation levels during the push-up plus exercise on stable and unstable surfaces. *Journal of sport rehabilitation.* 2016;24:1-16.
192. Hébert LJ, Moffet, H., Dufour, M., & Moisan, C. Acromiohumeral distance in a seated position in persons with impingement syndrome. *JMRI.* 2003;18(1):72-79.
193. Ebaugh DD, McClure, P.W., & Karduna, A.R. Effects of shoulder muscle fatigue caused by repetitive overhead activities on scapulothoracic and glenohumeral kinematics. *J Electromyogr Kinesiol.* 2006;16(3):224-235.
194. St-Pierre C, Dionne, C.E., Desmeules, F., & Roy, J.S. Reliability, validity, and responsiveness of a Canadian adaptation of the Western Ontario Rotator Cuff (WORC) index. *Journal of Hand Therapy.* 2015;28(3):292-298.
195. Michener LA, McClure, P.W., & Karduna, A.R. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. *Clin Biomech.* 2013;18(5):623-632.
196. Health IfW. The DASH Outcome Measure. Available at: www.dash.iwh.on.ca.
197. Beaton DE, Katz, J.N., Fossel, A.H., Wright, J.G., Tarasuk, V., & Bombardier, C. . Measuring the whole or the parts? Validity, reliability, and responsiveness of the Disabilities of the Arm, Shoulder, and Hand outcome measure in different regions of the upper extremity. *J Hand Ther.* 2001;14(2):128-146.

198. Wewers ME, & Lowe, N.K. A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing and Health.* 1990;13:227-236.
199. Nagatomi T, Mae, T., Nagafuchi, T., Yamada, S.I., Nagai, K. et al. . Shoulder manual muscle resistance test cannot fully detect muscle weakness *Knee Surg Sports Traumatol Arthrosc.* 2017;25(7):2081-2088.
200. Roy JS, MacDermid, J.C., Orton, B., Tran, T., Faber, K.J., Dosdowech, D. et al. The concurrent validity of a hand-held dynamometer versus a stationary dynamometer in testing isometric shoulder strength. *J Hand Ther.* 2009;22(4):320-326.
201. Kamper SJ, Maher, C., & Mackay, G. Global rating of change scales: A review of strengths and weaknesses and consideration for design. *J Man Manip Ther.* 2009;17(3):163-170.
202. Forces CA. Canadian Armed Forces - Test FORCE - Physical Fitness Standards. *CFMWS · SBMFC 2017*. Available at: https://www.cfmws.com/en/AboutUs/PSP/DFIT/Fitness/FORCEprogram/Pages/FAQs.aspx. Accessed 29 May 2017.
203. Hsu JE, Nacke, E., Park, M.J., Sennett, B.J., Huffman, G.R. The Disabilities of the Arm, Shoulder, and Hand questionnaire in intercollegiate athletes: validity limited by ceiling effect. *J Shoulder Elbow Surg.* 2010;19(3):349-354.
204. Scmitt JSDF, R.P. . Reliable change and minimum importance difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *J Clin Epidemiol.* 2004;57(10):1008-1018.
205. Kirkley A, Alvarez C, Griffin S. The development and evaluation of a disease-specific quality-of-life questionnaire for disorders of the rotator cuff: The Western Ontario Rotator Cuff Index. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine.* Mar 2003;13(2):84-92.
206. Razmjou H, Bean, A., van Osnabrugge, V., MacDermid, J.C., & Holtby, R. Cross-sectional and longitudinal construct validity of two rotator cuff disease-specific outcome measures. *BMC Musculoskeletal Disorders.* 2006;13(7):26.
207. Mintken PE, Glynn, P., & Cleland, J.A. Psychometric properties of the shortened disabilities of the Arm, Shoulder, and Hand Questionnaire (QuickDASH) and Numeric Pain Rating Scale in patients with shoulder pain. . *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons [et al]*. 2009;18(6):920-926.
208. Hancock MJ, Maher, C.G., Latimer, J., McLachlan, A.J., Cooper, C.W., Day, R.O., Spindler, M.F., & McAuley, J.H. Assessment of diclofenac or spinal manipulative therapy, or both, in addition to recommended first-line treatment for acute low back pain: a randomised controlled trial. *Lancet.* 2007;370(9599):1638-1643.
209. Costa LO, Maher, C.G., Latimer, J., Ferreira, P.H., Ferreira, M.L., Pozzi, G.C., & Freitas, L.M. Clinimetric testing of three self-report outcome measures for low back pain patients in Brazil: which one is the best? *Spine (Phila Pa 1976).* 2008;33(22):2459-2463.
210. Hébert LJ. *Évaluation de la force musculaire et dynamomètres manuels : Concepts de base et applications pratiques*. 3e éd. ed. ed: INVENTUM, Bibliothèque nationale du Québec et Bibliothèque et Archives Canada; 2012.
211. Farrar JT, Young, J.P. Jr., LaMoreaux, L., Werth, J.L., & Poole, R.M. . Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain.* 2001;94(2):149-158.
212. Kamkar A, Irrgang, J.J., & Whitney, S.L. Nonoperative management of secondary shoulder impingement syndrome. *J Orthop Sports Phys Ther.* 1993.;17:212-224.

213. Boon AJ, & Smith, J. Manual scapular stabilization: its effects on shoulder rotational range of motion. *Archives of Physical Medicine and Rehabilitation.* 2000;81(7):978-983.
214. Hanchard N, Cummins, J., & Jeffries, C. . Evidence-based clinical guidelines for the diagnosis, assessment and physiotherapy management of shoulder impingement syndrome. *Physiotherapy.* 2005;98(2):117-120.
215. Sanders B, Bandy, W.D. Chapter 8: Closed-Kinetic-Chain Exercises. *Therapeutic exercise for physical therapist assistans: Techniques for intervention.* Vol 2nd Edition. Baltimore, USA: Lippincott Williams & Wilkins; 2007.
216. Riemann BL, & Lephart, S.M. The sensorimotor system part II: the role of proprioception in motor control and functional joint stability. *J Athl Train.* 2002;37(1):80-84.
217. Aman JE, Elangovan, N., Yeh, I.L., & Konczak, J. The effectiveness of proprioceptive training for improving motor function: a systematic review. *Front Hum Neurosci.* 2014;8(Article 1075):1-18.
218. Kuhn JE. Exercise in the treatment of rotator cuff impingement: a systematic review and a synthesized evidence-based rehabilitation protocol. *Journal of Shoulder and Elbow Surgery.* 2009;18(1):138-160.
219. Miyasaka J, Arai, R., Ito, T., Shingu, M., Hasegawa,S., et al. Isometric muscle activation of the serratus anterior and trapezius muscles varies by arm position: a pilot study with healthy volunteers with implcations for rehabilitation. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons.* 2017.
220. Cools AM, Dewitte, v., Lanszweert, F., Notebaert, D., Roets, A. et al. Rehabilitation of scapular muscle balance - which exercises to prescribe? *Am J Sports Med.* 2007;35:1744-1751.
221. De May K, Cagnie, B., Danneels, L.A., Cools, A.M., Van de Velde, A. Trapeizus muscle timing during selected shoulder rehabilitation exercises. *J Orthop Sports Phys Ther.* 2009;39:743-752.
222. Kibler WB, Sciascia, A.D., Uhl, T.L., Tambay, N., & Cunningham, T. Electromyographic analysis of specigic exercises for scapular control in early phases of shoulder rehabilitation. *Am J Sports Med.* 2008;36:1789-1798.
223. Oberlander MA, Chisar, M.A., & Cambell, B. Epidemiology of shoulder injuries in throwing and overhead athletes. *Sport Medicine and Arthroscopic Review.* 2000;8(2):115-123.
224. Westrick RB, Miller, J.M., Carow, S.D., & Gerber, J.P. Exploration of the Y-balance test for assessment of upper quadrant closed kinetic chain performance. *Int J Sports Phys Ther.* 2012;7(2):139-147.
225. Dover G, & Powers, M.E. Reliability of joint position sense and force-reproduction measures during internal and external rotation of the shoulder. . *Journal of Athletic Training.* 2003;38(4):304-310.
226. Riemann BL, & Lephart, S.M. The sensorimotor system, part 1: the physiological basis of functional joint stability. *Journal of Athletic Training.* 2002;37(1):71-79.
227. Franco PG, Santos, K.B., & Rodacki, A.L Joint position sense, perceived force level and two-point discrimination tests of young and active elderly adults. *Braz J Phys Ther* 2015;19(4):304-310.
228. Arzi H, Kasovsky, T., Pritsch, M.,& Liebermann, D.G. . Movement control in patients with shoulder instability: a comparison between patients after open surgery and nonoperated patients. *J Shoulder Elbow Surg* 2014;23:982-992.
229. Williams PL, & Warwick, R. . *Gray's Anatomy*. Philadelphia: W.B Saunders Company; 1986.

230. Vafadar AM, Côté, J.N., & Archambault, P.S. The effect of muscle fatigue on position sense in an upper limb multi-joint task. *Motor Control.* 2012;16:265-283.
231. Ashton-Miller JA, Wojtys, E.M., Huston, L.J., & Fry-Welch, D. Can proprioception really be improved by exercises? *Knee Surg, Sports Traumatol, Arthrosc.* 2001(9):128-136.
232. Ayres AJ. *Sensory integration and learning disorders.* Los Angeles: Western Psychological Services; 1972.
233. Lephart SM, & Jari, R. The role of proprioception in shoulder instability. . *Operative Techniques in Sports Medicine* 2002;10(1):2-4.
234. Blanche EI, Bodison, S., Chang, M.C., & Reinoso, G. . Development of the Comprehensive Observations of Proprioception (COP): Validity, Reliability, and Factor Analysis. *Am J Occup Ther.* 2012;66(6):691–698.
235. Elangovan N, Hermann, A., & Konczak, J. Assessing proprioceptive function: evaluating joint position matching methods against psychophysical thresholds. *Phys Ther.* 2014;94(4):553-561.
236. Cappellino F, Paolucci, T., Zangrando, F., Iosa, M., Adriani, E., Mancini, P., Bellelli, A., & Saraceni, V.M. Neurocognitive rehabilitative approach effectiveness after anterior cruciate ligament reconstruction with patellar tendon. A randomized controlled trial. *Eur J Phys Rehabil.* 2012;48(1):17-30.
237. McCaskey MA, , Schuster-Amft, C., Wirth, B., Suica, Z., & de Bruin, E.D. . The effectiveness of proprioception exercises on pain and function in chronic neck - and low back pain rehabilitation: a systematic review. *BMC Musculoskeletal Disorders.* 2014;15(382).
238. Gokeler A, Benjaminse, A., Hewett, T.E., Lephart, S.M., Engebretsen, L., Ageberg, E., Engelhardt, M., Arnold, M.P., Postema, K., Otten, E., & Dijkstra, P.U. . Proprioceptive deficits after ACL injury: are they clinically relevant? . *Br J Sports Med.* 2012;46(3):180-192.
239. Hillier S, Immink, M., & Thewlis, D. Assessing Proprioception: A Systematic Review of Possibilities. *Neurorehabil Neural Repair.* 2015;29(10):933-949.
240. Droin JM, Valocich-mcLeod, T.C., Schultz, S.J., Gansneder, B.M., & Perrin, D.H. . Reliability and validity of the Biodex system 3 pro isokinetic dynamometer velocity, torque, and position measurements. *Eur J Appl Physiol* 2004;91:22-29.
241. Feiring DC, Ellenbecker, T.S., & Dersheid, G.L. Test-retest reliability of the Biodex isokinetic dynamometer.*J Orthop Sports Phys Ther.* 1990;11:298–300.
242. Patterson LA, & Spivey, W.E. Validity and reliability of the LIDO active isokinetic system. . *J Orthop Sports Phys Ther.* 1992;15:32–36.
243. Timm KE, Gennrich, P., Burns, R., & Fyke, D. . The mechanical and physiological performance reliability of selected isokinetic dynamometers. *Isokin Exerc Sci.* 1992;2:182–190.
244. Liberati A, Altman D.G., Tetzlaff J., Mulrow, C. Gøtzsche et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Ann Intern Med.* 2009;151:W-65–W-94.
245. Aydin T, Yildiz, Y., Yanmis, I., Yildiz, C., Kalyon, T.A. . Shoulder proprioception: a comparison between the shoulder joint in healthy and surgically repaired shoulders. *Arch Orthop Trauma Surg.* 2001(121):422-425.
246. Kmet LM, Lee, R.C., & Cook, L.S. . Standard quality assessment criteria for evaluating primary research papers from a variety of fields. *Edmonton: Alberta Heritage Foundation for Medical Research (AHFMR)* 2004;HTA Initiative #13
247. Terwee CB, Mokkink, L.B., Knol, D.L., Ostelo, R.W.J.G., Bouter, L.M., & de Vet, H.C.W. Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for the COSMIN checklist. . *Qual Life Res* 2012(21):651-657.

248. Mokkink LB, Terwee, C.B., Patrick, D.L., Alonso, J., Stratford, P.W., Knol, D.L., Ostelo, R.W.J.G., Bouter, L.M., & de Vet, H.C.W. Cosmin checklist manual. . Available at: http://www.cosmin.nl/COSMIN checklist.html. .
249. Fabis J. R, R., Fabis, A., Zwierzchowski, J., Kubiak, G., Stanula, A., Polguj, M., & Maciej, R. Shoulder proprioception – lessons we learned from idiopathic frozen shoulder. *BMC Musculoskeletal Disorders.* 2016;17:123-131.
250. Han J, Anson, J., Waddington, G., & Adams, R. . Proprioception performance of bilateral upper lower limb joints: side-general and site specific effects. *Exp Brian Res* 2013(226):313-323.
251. Sole G, Osborne, H., & Wassinger, C. The effect of experimentally-induced subacromial pain on proprioception. *Manual Therapy.* 2015;20:166-170.
252. Deng HR, & Shih, Y.F. . Test validity and intra-rater reliability in the measurement of scapular position sense in asymptomatic young adults. *Manual Therapy* 2015;20:503-507.
253. Kaya D, Callaghan, M. J., Donmez, G., & Doral, M.N. Shoulder joint position sense is negatively correlated with free-throw percentage in professional basketball players. *Isokin Exerc Sci.* 2012;20:189-196.
254. Zanca GG, Mattiello, S.M., & Karduna, A.R. Kinesio taping of the deltoid does not reduce fatigue induced deficits in shoulder joint position sense. *Clinical Biomechanics.* 2015;30:903-907.
255. Lönn J, Crenshaw, A.G., Djupsjobacka, M., & Johnansson, H. . Reliability of position sense testing assessed with a fully automated system. *Clin Physiol.* 2000;20(1):30-37.
256. Ramsay JRE, & Riddoch, M.J. . Position-matching in the upper limb: professional ballet dancers perform with outstanding accurary. *Clinical Rehabilitation* 2001;15:324-330.
257. Voight ML, Hardin, J.A., Blackburn, T.A., Tippett, S., & Canner, G.C. The effects of muscle fatigue on and the relationship of arm dominance to shoulder proprioception. . *JOSPT* 1996;23(6):348-353.
258. Bradley T, Baldwick, C., Fischer, D., Murrell, G.A.C. Effect of taping on the shoulders of Australian football players. *Br J Sports Med.* 2009;43:735-738.
259. Nodehi-Moghadam A, Khaki, N., Kharazmi, A., & Eskandari, Z. . A comparative study on shoulder rotational strength, range of motion and proprioception between the throwing athletes and non-athletic persons. . *Asian J Sports Med.* 2012;4(1):34-41.
260. Allegrucci M, Whitney, S.L., Lephart, S.M., Irrgang, J.J., Fu, F.H. Shoulder Kinesthesia in Healthy Unilateral Athletes Participating in Upper Extremity Sports. *JOSPT.* 1995;21(4):220-227.
261. Herrington L, Horsley, I., Whitaker, L., & Rolf, C. . Does a tackling task effect shoulder joint position sense in rugby players. . *Physical Therapy Sport.* 2008;9:67-71.
262. Edmonds G, Kirkley, A., Birmingham, T.B., & Fowler, P.J. The effect of early athroscopic stabilization compared to nonsurgical treatment of proprioception after primary traumatic anterior shoulder dislocation. . *Knee Surg Sports Traumatol Arthrosc* 2003;11:116-121.
263. Smith TO, Davies L, Hing CB. A systematic review to determine the reliability of knee joint position sense assessment measures. *The Knee.* Jun 2013;20(3):162-169.
264. Wodowski AJ, Swigler, C.W., Liu, H., Nord, K.M., Toy, P.C., & Mihalko, W.M. Proprioception and knee arthroplasty: A literature review. *Orthop Clin North Am.* 2016;47(2):301-309.
265. Schiftan GS, Ross, L.A., & Hahne, A.J. The effectivness of proprioceptive training in preventing ankle sprains in sporting populations: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport.* 2015;18:238-244.

266. Gibson JJ. *The ecological approach to visual perception.* Hillsdale, NJ: Erlbaum; 1979.
267. Schmuckler MA. What is ecological validity? A dimensional analysis. . *Infancy.* 2001;2(4):419-436.
268. Collins DF, Refshauge, K.M., Todd, G., Gandevia, S.C., . Cutaneous receptors contribute to kinesthesia at the index finger, elbow, and knee. . *J Neurophysiol* 2005;94(3):1699-1706.
269. Proske UG, S.C. The proprioceptive senses: their roles in signaling body shape,body position and movement, and muscle force. *Physiol Rev.* 2012;92:1651-1697.
270. Winter JA, Allen,T.J.,andProske,U. Muscle spindle signals combine with the sense of effort to indicate limb position. *J Physiol.* 2005;568:1035-1046.
271. Proske UG, S.C. The kinaesthetic sense. *J Physiol.* 2009;587:4139-4146.
272. Langan J. Older adults demonstrate greater accuracy in joint position matching using self-guided movements. *Human Movement Science.* 2014;36:97-106.
273. Han J, Waddington, G., Anson, J., & Adams, R. Level of competitive success achieved by elite athletes and multi-joint proprioceptive ability. *J Sci Med Sport.* 2015;18(1):77-81.
274. Riemann BL, Myers, J.B., & Lephart, S.M. Sensorimotor system measurement techniques. *Journal of Athletic Training.* 2002;37(1):85-98.
275. Johnson EO, & Soucacos, P.N. *Proprioception.*; 2010.
276. Balke M, Liem, D., Dedy, N., Thorwesten, L., Balke, M., Poetzl, W., & Marquardt, B. . The laser-pointer assisted angle reproduction test for evaluation of propriocetive shoulder function in patients with instability. *Arch Orthop Trauam Surg.* 2011;131:1077-1084.
277. Glad D, Skillgate, E., & Holm, L.W. The occurence and severity of musculoskeletal disorders in Swedish military personnel during peacekeeping operations in Afghanistan. *Eur Spine J.* 2012;21(4):739-744.
278. Almekinders LC. Tendinitis and other chronic tendinopathies. *J Am Acad Orthop Surg.* 1998;6(3):157-164.
279. Fredberg U, & Stengaard-Pedersen, K. Chronic tendinopathy tissue pathology, pain mechanisms, and etiology with a special focus on inflammation. *Scandinavian journal of medicine & science in sports.* 2008;18(1):3-15.
280. Raymond MH, Demers, L., & Feldman, D.E. Waiting list management practices for home-care occupational therapy in the province of Quebec, Canada. *Health Soc Care Community.* 2016;24:154-164.
281. Rastall M, & Fashanu, B. Hospital physiotherapy outpatient department waiting lists. *Physiotherapy.* 2001;87(563-572.).
282. Abdulla SY, Southerst, D., Côté, P., Shearer, H.M., Sutton, D et al. . Is exercise effective for the management of subacromial impingement syndrome and other soft tissue injuries of the shoulder? A systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *Man Ther.* 2015;20(5):646-656.
283. Grant HJ, Arthur, A., & Pichora, D.R. Evaluation of interventions for rotator cuff pathology: a systematic review. *J Hand Ther.* 2004;17(2):274-299.
284. Franchignoni F, Vercelli, S., Giordano, A., Sartorio, F., Bravini, E. et al. Minimally clinically important difference of the disabilities of the arm, shoulder, and hand outcome measure (DASH) and its shorterned version (QuickDASH). *J Orthop Sports Phys Ther.* 2014;44(1):30-39.
285. Bas de Witte P, Henseler, J.F., Nagels, J., Vliet Vlieland, & Nelissen, R. The Western Ontario Rotator Cuff (WORC) score in rotator cuff disease patients - A comprehensive reliability and responsiveness validation study. *Am J Sports Med.* 2012;40:1611-1619.

286. Goldgrub R, Côté, P., Sutton, D., Wong, J.J., Yu., H. et al. The Effectiveness of Multimodal Care for the Management of Soft Tissue Injuries of the Shoulder: A Systematic Review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *J Manipulative Physiol Ther.* 2016;39(2):121-139.
287. Huber EO, Roos, E.M., Meichtry, A., de Bie, R.A., & Bischoff-Ferrari, H.A. Effect of preoperative neuromuscular training (NEMEX-T JR) on functional outcome after total knee replacement: an assessor-blindded randomized controlled trial. *BMC Musculoskeletal Disorders.* 2015;16(101).
288. Kromer T, O., de Bie, R.A., & Bastiaenen, C.H.G. Effectiveness of individualized physiotherapy on pain and functioning compared to a standard exercise protocol in patients presenting with clinical signs of a subacromial impingement syndrome. A randomized controlled trial. *BMC Musculoskeletal Disorders.* 2010;11(114):1-13.
289. Camargo PR, Alburquerque-Sendin, F., Avila, M.A., Haik, M.N., Vieira, A., & Salvini, T.F. Effects of stretching and strengthening exercises, with and without manual therapy, or scapular kinemtics, function, and pain in individuals with shoulder impingement: a randomized control trial. *J Orthop Sports Phys Ther.* 2015;45(12):984-997.
290. Chapter 13: The professional military ethic. In: Weber JA, & Eliasson J., ed. *Handbook of Military Administration.* First Edition. ed: Routledge.; 2007: page 304. .
291. Haakstad LAH, Torset, B., & Bo, K. What is the effect of regular group exercise on maternal psychological outcomes and common pregnancy complaints? An assessor blinded RCT. *Midwifery.* 2016;32:81-86.
292. Farrance C, Tsofliou, F., & Clark, C. Adherence to community based group exercise interventions for oder people: a mixed-methods systematic review. *Preventive Medicine.* 2016;87:155-166.
293. Brach JS, Perera, S., Gilmore, S., VanSwearingen, J.M., Brodine, D. et al. Effectiveness of a timing and coordinated group exercise program to imrpove mobility in community-dwelling older adults: A randomized clinical trial. *JAMA Intern Med.* 2017.
294. Hurley DA, O'Donoghue, G., Tully, M.A., Moffett, J.K.,van Mechelen, W. et al. A walking programme and a supervised exercise class versus usual physiotherapy for chronic low back pain: a single-blinded randomised controlled trial. (The Supervised Walking In comparison to Fitness Traininig for Back Pain (SWIFT) Trial). *BMC Musculoskeletal Disorders.* 2009;10(79).
295. Osborne LA, Whittall, C.M., Emanuel, R., Emery, S., & Reed, P. Randomised control trial of the impact of a brief tele-support intervention on initial attendance at physiotherapy group sessions for pelvic floor problems. *Arch Phys Med Rehabil.* 2017.
296. Sandford FM, Sanders, T.A.B., & Lewis, J.S. Exploring experiences, barriers, and enablers to home- and class-based exercise in rotator cuff tendinopathy: A qualitative study. *J Hand Ther.* 2017;30:193-199.
297. Bachasson B, Singh, A., Shah, S.B., Lane, J.G., & Ward, S.R. The role of the peripheral and central nervous system in rotator cuff disease. *Journal of shoulder and elbow surgery / American Shoulder and Elbow Surgeons.* 2015;24:1322-1335.
298. Berth A, Pap, G., Awiszus, F., & Neumann, W. Central motor deficits of the deltoid muscle in patients with chronic rotator cuff tears. *Acta Chir Orthop Traumatol Cech.* 2009;76(6):456-461.
299. Groth GN, & Wulf, M.B. Compliance with hand rehabilitation: health beliefs and strategies. *J Hand Ther.* 1995;8(1):18-22.

300. Kidd MO, Bond, C.H., Bell, M.L. Patient's perspectives of patient-centredness as important in musculoskeletal physiotherapy interactions: a qualitative study. *Physiotherapy.* 2011;97(2):154-162.
301. Borg GA. Psycophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise.* 1982;14:377-381.
302. Bialosky JE, Bishop, M.D., Price, D.D., Robinson, M.E., & George, S.Z. The mechanisms of manual therapy in the treatment of musculoskeletal pain: a comprehensive model. *Man Ther.* 2009;14(5):531-538.
303. Ginn KA, & Cohen, M.L. Exercise therapy for shoulder pain aimed at restoring neuromuscular control: a randomized comparative clinical trial. *J Rehabil Med.* 2005;37:115-122.
304. Kelly SM, Wrightson, P.A., & Meads, C.A. Clinical outcomes of exericse in the management of subacromial impingement syndrome: a systematic review. *Clinical rehabilitation.* 2010;24(2):99-109.
305. Domingo A, Marriott E, de Grave RB, Lam T. Quantifying lower limb joint position sense using a robotic exoskeleton: a pilot study. *IEEE International Conference on Rehabilitation Robotics : [proceedings].* 2011;2011:5975455.
306. Lin CH, Chiang SL, Lu LH, Wei SH, Sung WH. Validity of an ankle joint motion and position sense measurement system and its application in healthy subjects and patients with ankle sprain. *Computer methods and programs in biomedicine.* Jul 2016;131:89-96.
307. Benjaminse A, Sell TC, Abt JP, House AJ, Lephart SM. Reliability and precision of hip proprioception methods in healthy individuals. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine.* Nov 2009;19(6):457-463.

SUPPLEMENTARY ANNEX I

Shoulder proprioception outcome measures and general psychometric findings of included studies

Author & year	Population of scientific protocol	Outcome	Direction of movement	Equipment	Error measured	Psychometric Property
Dover & Powers 2003	31 healthy college level students (n=31) Dominant shoulder only	AJPS (ipsi)	90% of IR and ER at 90° of shoulder abduction and 90° of elbow flexion	Handheld inclinometer	Angular displacement error in degrees	Inter session. Intra-rater reliability. JPS for 90% of maximum IR (ICC=0.981) and 90% of maximum ER (ICC=0.984)
Vafadar et al. 2016	25 healthy participants (men = 11 and women =14), 22 right-handed and 3 left-handed. (n=25) Dominant shoulder only	AJPS (ipsi)	Flexion (Low: 55+/- 10°, Medium 90+/-10°, and High: 125 +/-10°)	Laser pointer, inclinometer, goniometer and a VICON motion capture system	Angular displacement error. Displacement in either cm, or joint angles. Basic geometry (COS, SIN, TAN) were used to calculate precise joint angular displacements	Inter session. Reliability: Laser pointer ICC=0.86 (inter) and ICC=0.78 (intra), Inclinometer ICC 0.67 (intra) and ICC=0.70 (inter), and goniometer ICC=0.60 (intra) and 0.50 (inter). SEM for all methods ranged from 0.6-1.2 degrees. MDC95s 1.8 degrees (laser pointer), 3.3 degrees (goniometer), and 2.8 degrees (inclinometer). Concurrent validity: Pearson product-moment correlation coefficient (95% CI): laser pointer (r=0.85), goniometer (r=0.77), inclinometer (r=0.8)
Lonn et al. 2000	10 healthy university level students (5 males, 5 females). (n=10) Right handed only	AJPS and PJPS (ipsi) 1. Passive / active 2. passive / passive 3. Active-assisted. 4. active / active	Horizontal ABD (starting position 0°, target positions 32° and 64°) and horizontal ADD (starting position 80°, towards 48° and 16°)	Fabricated laboratory apparatus with a positional data recording system (FASTRAK)	Angular displacement error in degrees	Inter session. Intra-rater reliability: ICCs range from 0.40-0.61. Passive-active: ICC=0.53 (SEM 0.76°), passive: ICC=0.56 (SEM: 1.02°), semi-passive: ICC=0.61 (SEM: 0.51°), Active: ICC=0.40 (SEM 0.54°), Combined: ICC=0.55 (SEM: 0.41°)
*Sole et al. 2015	30 healthy college level participants (n=30) Dominant shoulder only	TTDPM and RPP (ipsi)	60° of abduction in scapular plane. RPP: Starting position of 40° of ER, target 60° of ER. TTDMD idem for RPP but starting position 20° of ER	Biodex 3 (Pro isokinetic dynamometer)	Angular displacement error (both constant and absolute) in degrees	Intra session. Intra-rater reliability. RPP: ICC at 95% CI= 0.79 (0.56-0.90) and a SEM of 0.98° (absolute angular error). TTDPM: ICC (95%CI) of 0.92 (0.83-0.96) and SEM of 0.15°
*Han et al. 2013	12 healthy university student volunteers (6 males, 6 females) (n=24) Bilateral evaluation	AJPS (ipsi)	Flexion	Purpose built AMEDA apparatus	Non-parametric signal detection method (difference between stimulus pairs 1-2, 2-3, 3-4, 4-5) in degrees	Inter session. Intra-rater reliability. Test-retest discrimination score for the shoulder ICC=0.86 (p=0.79)
*Herrington et al. 2008	5 healthy professional union rugby players (n=5) Unclear if bilateral evaluation	AJPS (ipsi)	ER of 45° and 80° at 90° of ABD	Fuji Finepix S304 camera, analysed using Image computer software	Angular displacement error	Intra session. Intra-tester reliability, correlation between measurements (r=0.98 p=0.001)

Author & year	Population of scientific protocol	Outcome	Direction of movement	Equipment	Error measured	Psychometric Property
*Anderson & Wee 2011	10 participants with chronic rotator cuff pathology (CRCP), (n=20) Bilateral evaluation	AJPS (ipsi)	ABD in the scapular plane at 40° and 100°	Vicon M series camera with 22-mm lens and reflective markers (10mm diameter)	Angular displacement error (Relative error, absolute error, variable error)	Inter session. Intra-rater reliability with CRCP participants. Affected limbs 40° ICC = 0.81 (SEM: 1.3° +/- 1.2°), 100° ICC=0.54 (SEM: 2.7°+/-2.6°), Non-affected limbs 40° ICC=0.81 (SEM: 2.0°+/-2.1°), 100° ICC=0.90 (SEM: 0.9°+/-0.9°)
Deng & Shih 2015	10 healthy college level participants (1 male, 9 females) (n=20) Bilateral evaluation	AJPS (ipsi)	Scapular retraction, protraction, elevation, and depression	Fabricated laboratory apparatus. Liberty electromagnetic tracking device with a 120 Hz sampling rate. Motion Monitor software used to record and analyze 3D kinematic data	Linear displacement of middle finger (in cm) with regards to scapular movement	Inter session. Intra-rater reliability. 3D measurements of scapular repositioning error ICC= 0.56-0.99 (SEM 0.16-1.18° and 0.02-0.20 cm, MDC95 = 0.44 -3.27° and 0.06-0.58cm). Concurrent validity (Pearson's product-moment correlation coefficients r=0.59-0.94. All measurements significantly correlated except for scapular elevation on dominant shoulder (r=0.61) and scapular protraction on dominant shoulder (r=0.59)
*Nodehi-Moghadam et al. 2012	10 national woman's volleyball players (n=10) Right shoulder only	TTDPM and RPP (ipsi)	Midrange ER in 90° of shoulder abduction, 90° of elbow flexion, and forearm pronated	Continuous passive motion device (CPM)	Angular displacement error in degrees	Inter session. Intra-rater reliability. RPP: ICC=0.90, (SEM=0.29°) TTDPM: ICC=0.92 (SEM 0.25°)
*Suprak et al. 2006	22 healthy participants (12 males, 10 females) (n=22) Dominant shoulder only	AJPS (ipsi)	Scaption (30°, 50°,70°,90°, and 110°) and flexion (0°,20°,35°,60°,80°, and 90°)	FASTRAK 3Space magnetic tracking system	Angular displacement error in degrees. Magnitude of reposition error in degrees calculated via kinematic data and transformation matrices (3D vectors)	Intra session. Intra-rater reliability. ICCs range from -011 to 0.69 and SEM from 1.90° to 4.07°
*Allegrucci et al. 1995	10 healthy college level athletes (baseball players, quarterbacks, tennis players) (n=20) Bilateral evaluation	TTDPM (ipsi)	IR and ER at 90° of ABD	Proprioceptive testing device (motor driven goniometer, passively moving the shoulder at 5°/s)	Angular displacement error in degrees	Intra session. Intra-rater reliability using a fixed effect model. ER at 0°: ICC = 0.83, ER at 75°: ICC=0.87; IR at 0°: ICC=0.86, IR at 75°: ICC=0.92
*Edmonds et al. 2003	24 participants with multidirectional instability (n=24) Pathological shoulder only	TTDPM and RPP (ipsi)	30° and 60° of ER at 90° of ABD	Modified isokinetic dynamometer (Cybex 6000)	TTDPM and RPP: Angular displacement error in degrees	Intra session. Intra-rater reliability: TTDPM: ICC range: 0.95-0.97 RPP: ICC range: 0.78-0.92
*Ramsay & Riddoch 2001	4 pictures of healthy participants (n=8) Bilateral evaluation	AJPS (contra)	Flexion, mid range, and ABD in the coronal plane	Nikon F801 camera. Analysis using Helix 360 angle measure and a goniometer	Angular displacement error in degrees	Intra session. Inter-rater reliability (4 physiotherapists measured 16 joints on 4 pictures, therefore 8 shoulders) Cronbach's alpha = 0.99. Intra-rater reliability Cronbach's alpha=0.99

Author & year	Population of scientific protocol	Outcome	Direction of movement	Equipment	Error measured	Psychometric Property
*Voight et al. 1996	80 healthy college level participants (n=160) Bilateral evaluation	AJPS and PJPS (ipsi)	ER 75° at 90° of ABD (neutral pronation and supination)	Biodex 3 (Pro isokinetic dynamometer)	Angular displacement in degrees	Intra session. Intra-rater reliability ICC = 0.95
*Lephart et al. 1994	30 healthy participants (n=30) Unclear if bilateral evaluation	TTDPM and RPP (ipsi)	IR and 30° ER (at 90° of ABD and 90° flexion the of elbow)	Specifically designed proprioception device (PTD) (Using a digital microprocessor counter)	Angular displacement in degrees	Intra session. Intra-rater reliability: r=0.92
*Kaya et al. 2012	11 healthy participants (n=11) Unclear if bilateral evaluation	AJPS (Ipsi)	180° of F/ABD/ER to target angles of 160°, 135°, and 120°	Biodex 3 (Pro isokinetic dynamometer)	Angular displacement in degrees	Intra session. Intra-rater reliability. ICC = 0.716 (SEM 4.5°) with eyes open and ICC= 0.404 (SEM 3.87 °) with eyes closed
*Bradley et al. 2009	33 healthy male Australian football players (n=33) Unclear if bilateral evaluation	AJPS (Ipsi)	Position 1: 30° of flexion. Position 2: 90° of ABD and 90° of elbow flexion with 30° of IR. Position 3: 90° of ABD with 90° of elbow flexion with 90° of ER	Motion analysis system: Optotrak using LED markers placed on the back of the long and ring finger proximal phalanxes	Angular displacement in degrees	Intra session. The intra-rater reliability of the Optotrak system for all three positions with an ICC = 0.65-0.77 (mean: ICC = 0.87)
*Zanca et al. 2015	24 healthy participants (n=24) Unclear if bilateral evaluation	AJPS (ipsi)	Scaption Position 1: 50° Position 2: 70° Position 3: 90°	An App developed for Apple's 4th generation iPod touch. The App uses internal sensors (accelerometers and gyroscopes)	Angular displacement in degrees	Intra and inter session. Intra-rater reliability. Intra session 50° (ICC=0.75), 70° (ICC=0.65), 90° (ICC=0.79). Inter session 50° (ICC=0.64), 70° (ICC=0.80) and 90° (ICC=0.67)
*Fabis et al. 2016	20 healthy participants (n=40) Bilateral evaluation	APJS and PJPS (ipsi)	30° of IR and ER at 30° of ABD in scapular plane	Biodex 3 (Pro isokinetic dynamometer)	Angular displacement in degrees	Inter session. Inter-rater reliability. AJPS IR (ICC= 0.97), AJPS ER (ICC=0.95), PJPS IR (ICC=0.96), and PJPS ER (ICC=0.96)
*Morgan & Herrington 2014	6 healthy senior semi-professional male rugby players (n=6) Unclear if bilateral evaluation	AJPS (ipsi)	Relative angles of 45° and 20° off of the maximum range of ER at 90° of ABD	Digital photograph (Samsung Digimax A7 digital camera)	Angular displacement in degrees	Intra session. Intra-rater reliability. ICC=0.81 (CI =0 - 3.3°)
*Lephart et al. 2002	Healthy participants. Unclear how many shoulders evaluated	AJPS, PJPS, TTDPM, & PMJ (ipsi)	TDPM & PRJP: IR and ER. AJPS & PMJ: 20° flexion with 0° of humeral rotation (20° FLEX) or 90° of ABD with 90° of ER (90° ABD-ER)	TDPM & PRJP: Proprioception testing device. ARJP & PMJ: Electromagnetic tracking device and isokinetic dynamometer	TDPM & PRJP: Angular displacement in degrees AJPS & PMJ: 3D data (X,Y,Z) (in cm) and angular rotation using sensors on the humerus (in°)	Intra session. Intra-rater reliability of electromagnetic device for AJPS & PMJ: ICC= 0.61-0.8

Note: (*) Not a primary psychometric study. (n) Reflects the number of shoulders evaluated for the psychometric protocol.

SUPPLEMENTARY ANNEX II

Assessment of methodological quality (critical appraisal - Modified QualSyst) after consensus between evaluators.

	Checklist item and corresponding consensus score															
	1	2	3	4	5*	6*	7*	8	9*	10	11	12	13	14	Point	%
Anderson & Wee (2011)	2	2	2	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	20	100
Allegrucci et al. (1995)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	1	2	2	1	17	85
Bradley et al. (2009)	1	2	2	2	n/a	n/a	n/a	1	n/a	2	2	1	2	1	16	80
Dover & Powers (2003)	2	2	1	1	n/a	n/a	n/a	2	n/a	2	1	2	1	2	16	80
Edmonds et al. (2003)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	1	1	2	2	17	85
Fabis et al. (2016)	2	1	1	2	n/a	n/a	n/a	1	n/a	1	2	1	1	0	12	60
Han et al. (2013)	2	2	2	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	20	100
Herrington et al. (2008)	2	2	2	1	n/a	n/a	n/a	2	n/a	2	1	2	1	2	17	85
Deng & Shih (2015)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	19	95
Kaya et al. (2012)	2	2	2	2	n/a	n/a	n/a	2	n/a	2	2	2	2	1	19	95
Lephart et al. (1994)	1	2	1	1	n/a	n/a	n/a	2	n/a	1	2	1	2	1	14	70
Lephart et al. (2002)	1	2	1	2	n/a	n/a	n/a	2	n/a	1	2	1	2	2	16	80
Lonn et al. (2000)	2	2	1	1	n/a	n/a	n/a	2	n/a	2	2	2	2	2	19	95
Morgan & Herrington (2014)	2	2	2	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	20	100
Nodehi-Moghadam et al. (2012)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	2	1	2	2	18	90
Ramsay & Riddoch (2001)	2	2	2	2	n/a	n/a	n/a	1	n/a	2	2	1	2	1	17	85
Sole et al. (2015)	2	2	2	2	n/a	n/a	n/a	2	n/a	1	2	2	2	2	19	95
Suprak et al. (2005)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	1	2	2	2	18	90
Vafadar et al. (2016)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	19	95
Voight et al. (1996)	2	2	1	2	n/a	n/a	n/a	2	n/a	2	2	2	2	2	19	95
Zanca et al. (2015)	2	2	1	2	n/a	n/a	n/a	1	n/a	2	2	2	2	2	18	90

	Checklist item and corresponding consensus score														Point	%
	1	2	3	4	5	6	7	8	9	10	11	12 *	13 *	14 *		
Anderson & Wee (2011)	4	4	1	4	4	4	2	4	4	4	4	n/a	n/a	n/a	39	88.6
Allegrucci et al. (1995)	3	2	1	4	3	4	3	2	3	4	3	n/a	n/a	n/a	31	70.5
Bradley et al. (2009)	4	3	2	4	3	2	2	2	2	2	3	n/a	n/a	n/a	29	65.9
Dover & Powers (2003)	3	2	2	4	3	4	3	4	3	4	3	n/a	n/a	n/a	35	79.6
Edmonds et al. (2003)	3	4	1	4	2	2	2	2	2	2	3	n/a	n/a	n/a	27	61.4
Fabis et al. (2016)	3	2	1	4	2	4	3	4	3	2	3	n/a	n/a	n/a	31	70.4
Han et al. (2013)	3	2	1	4	2	4	3	4	4	4	3	n/a	n/a	n/a	34	77.2
Herrington et al. (2008)	3	2	1	4	1	4	3	4	3	4	3	n/a	n/a	n/a	32	72.7
Deng & Shih (2015)	3	2	1	4	1	4	3	4	3	4	3	n/a	n/a	n/a	32	72.7
Kaya et al. (2012)	4	4	1	4	2	2	2	2	2	2	3	n/a	n/a	n/a	28	63.6
Lephart et al. (1994)	3	2	2	4	2	2	2	2	2	2	2	n/a	n/a	n/a	25	56.8
Lephart et al. (2002)	3	2	1	4	2	2	2	2	2	4	3	n/a	n/a	n/a	27	61.3
Lonn et al. (2000)	3	2	1	4	4	4	3	4	4	4	4	n/a	n/a	n/a	37	84.1
Morgan & Herrington (2014)	3	2	1	4	2	4	3	4	3	4	3	n/a	n/a	n/a	33	75.0
Nodehi-Moghadam et al. (2012)	3	2	1	4	1	4	3	2	3	2	3	n/a	n/a	n/a	28	63.6
Ramsay & Riddoch (2001)	4	3	1	4	4	2	4	2	2	2	1	n/a	n/a	n/a	29	65.9
Sole et al. (2015)	3	2	2	4	2	2	2	2	3	2	3	n/a	n/a	n/a	27	61.3
Suprak et al. (2005)	3	2	1	4	3	4	3	2	4	4	3	n/a	n/a	n/a	33	75
Vafadar et al. (2015)	3	2	1	4	3	4	3	4	3	4	3	n/a	n/a	n/a	34	77.3
Voight et al. (1996)	3	2	3	4	3	2	3	2	3	4	3	n/a	n/a	n/a	32	72.7
Zanca et al. (2015)	3	2	1	4	4	4	3	2	4	4	3	n/a	n/a	n/a	34	77.3

Studies presented in alphabetic order. 4 points (Excellent), 3 points (Good), 2 points (Fair), 1 point (Poor), n/a not applicable.

Points is the sum of scores for each item. Score is the points divided by the maximum possible score (44).

1) Was the percentage of missing items given? 2) Was there a description of how missing items were handled? 3) Was the sample size included in the analysis adequate? 4) Were at least 2 measurements available? 5) Were the administrations independent? 6) Was the time interval stated? 7) Were patients stable in the interim period on the construct to be measured? 8) Was the time interval appropriate? 9) Were the test conditions similar for both measurements? 10) Were there any important flaws in the design or methods of the study? 11) Statistical methods: for continuous scores, was an intraclass correlation coefficient (ICC) calculated?

Terwee, CB., Mokkink, LB., Knol, DL., Ostelo, RWJG., Bouter, LM., & de Vet, HCW. (2012). Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for COSMIN checklist. *Qual Life Res.* 21: 651-657.
* Items removed to make the COSMIN 4-point scale Box B tailored for this research.

Studies presented in alphabetic order. 2 points (Yes), 1 point (Partial), 0 point (No), n/a: not applicable.

Points is the sum of scores for each item. Score is the points divided by the maximum possible score (20).

1) Question / objective sufficiently described? 2) Study design evident and appropriate? 3) Method of subject/comparison group selection or source of information/input variables described and appropriate? 4) Subject (and comparison group, if applicable) characteristics sufficiently described? 5) If interventional and random allocation was possible, was it described? 6) If interventional and blinding of investigators was possible, was it reported? 7) If interventional and blinding of subjects was possible, was it reported? 8) Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? Means of assessment reported? 9) Sample size appropriate? 10) Analytic methods described/justified and appropriate? 11) Some estimate of variance is reported for the main results? 12) Controlled for confounding? 13) Results reported in sufficient detail? 14) Conclusions supported by the results?
Kmet LM, Lee RC, Cook LS. Standard quality assessment criteria for evaluating primary research papers from a variety of fields. Alberta Heritage Foundation for Medical Research; 2004.
* Items removed to make the QualSyst tailored for this research.

SUPPLEMENTARY ANNEX III

Assessment of psychometric properties (critical appraisal - COSMIN 4-point scale, BOX B - Reliability) after consensus between evaluators.

	Checklist item and corresponding consensus score														Point	%
	1	2	3	4	5	6	7	8	9	10	11	12 *	13 *	14 *		
Anderson & Wee (2011)	4	4	1	4	4	4	2	4	4	4	4	n/a	n/a	n/a	39	88.6
Allegrucci et al. (1995)	3	2	1	4	3	4	3	2	3	4	3	n/a	n/a	n/a	31	70.5
Bradley et al. (2009)	4	3	2	4	3	2	2	2	2	2	3	n/a	n/a	n/a	29	65.9
Dover & Powers (2003)	3	2	2	4	3	4	3	4	3	4	3	n/a	n/a	n/a	35	79.6
Edmonds et al. (2003)	3	4	1	4	2	2	2	2	2	2	3	n/a	n/a	n/a	27	61.4
Fabis et al. (2016)	3	2	1	4	2	4	3	4	3	2	3	n/a	n/a	n/a	31	70.4
Han et al. (2013)	3	2	1	4	2	4	3	4	4	4	3	n/a	n/a	n/a	34	77.2
Herrington et al. (2008)	3	2	1	4	1	4	3	4	3	4	3	n/a	n/a	n/a	32	72.7
Deng & Shih (2015)	3	2	1	4	1	4	3	4	3	4	3	n/a	n/a	n/a	32	72.7
Kaya et al. (2012)	4	4	1	4	2	2	2	2	2	2	3	n/a	n/a	n/a	28	63.6
Lephart et al. (1994)	3	2	2	4	2	2	2	2	2	2	2	n/a	n/a	n/a	25	56.8
Lephart et al. (2002)	3	2	1	4	2	2	2	2	2	4	3	n/a	n/a	n/a	27	61.3
Lonn et al. (2000)	3	2	1	4	4	4	3	4	4	4	4	n/a	n/a	n/a	37	84.1
Morgan & Herrington (2014)	3	2	1	4	2	4	3	4	3	4	3	n/a	n/a	n/a	33	75.0
Nodehi-Moghadam et al. (2012)	3	2	1	4	1	4	3	2	3	2	3	n/a	n/a	n/a	28	63.6
Ramsay & Riddoch (2001)	4	3	1	4	4	2	4	2	2	2	1	n/a	n/a	n/a	29	65.9
Sole et al. (2015)	3	2	2	4	2	2	2	2	3	2	3	n/a	n/a	n/a	27	61.3
Suprak et al. (2005)	3	2	1	4	3	4	3	2	4	4	3	n/a	n/a	n/a	33	75
Vafadar et al. (2015)	3	2	1	4	3	4	3	4	3	4	3	n/a	n/a	n/a	34	77.3
Voight et al. (1996)	3	2	3	4	3	2	3	2	3	4	3	n/a	n/a	n/a	32	72.7
Zanca et al. (2015)	3	2	1	4	4	4	3	2	4	4	3	n/a	n/a	n/a	34	77.3

Studies presented in alphabetic order. 4 points (Excellent), 3 points (Good), 2 points (Fair), 1 point (Poor), n/a not applicable.

Points is the sum of scores for each item. Score is the points divided by the maximum possible score (44).

1) Was the percentage of missing items given? 2) Was there a description of how missing items were handled? 3) Was the sample size included in the analysis adequate? 4) Were at least 2 measurements available? 5) Were the administrations independent? 6) Was the time interval stated? 7) Were patients stable in the interim period on the construct to be measured? 8) Was the time interval appropriate? 9) Were the test conditions similar for both measurements? 10) Were there any important flaws in the design or methods of the study? 11) Statistical methods: for continuous scores, was an intraclass correlation coefficient (ICC) calculated?

Terwee, CB., Mokkink, LB., Knol, DL., Ostelo, RWJG., Bouter, LM., & de Vet, HCW. (2012). Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for COSMIN checklist. *Qual Life Res.* 21: 651-657.
* Items removed to make the COSMIN 4-point scale Box B tailored for this research.

SUPPLEMENTARY ANNEX IV

Assessment of psychometric properties (critical appraisal - COSMIN 4-point scale, BOX H - Criterion validity) after consensus between evaluators

	Checklist item and corresponding consensus score								
	1	2	3	4	5	6	7	Point	%
Vafadar et al. (2016)	3	2	1	2	4	1	1	12	50
Deng & Shih (2015)	3	2	1	2	4	1	1	12	50

Studies presented in alphabetic order. 4 points (Excellent), 3 points (Good), 2 points (Fair), 1 point (Poor), n/a not applicable.

Points is the sum of scores for each item. Score is the points divided by the maximum possible score (28).

1) Was the percentage of missing items given? 2) Was there a description of how missing items were handled? 3) Was the sample size included in the analysis adequate? 4) Can the criterion used or employed be considered as a reasonable "gold standard"? 5) Were there any important flaws in the design or methods of the study? 6) Statistical methods: for continuous scores, were correlations, or the area under the receiver operating curve calculated? 7) For dichotomous scores: were sensitivity and specificity determined?

Terwee, CB., Mokkink, LB., Knol, DL., Ostelo, RWJG., Bouter, LM., & de Vet, HCW. (2012). Rating the methodological quality in systematic reviews of studies on measurement properties: a scoring system for the COSMIN checklist. *Qual Life Res.* 21: 651-657.

SUPPLEMENTARY APPENDICES

APPENDIX A: Recruitment poster for the military participants, Quebec

Projet de recherche approuvé par le Comité d'éthique à la recherche du CIRRIS. # d'éthique: 2015-446
et Surgeon General Health Research Program (SGHRP) (Oct 2015)

UNIVERSITÉ LAVAL

CIRRIS

PROJET: EFFICACITÉ D'UN PROGRAMME DE RENFORCEMENT ET DE CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR SUR LA FONCTION DE L'ÉPAULE DE PERSONNES AYANT UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS: UN ESSAI CLINIQUE RANDOMISÉ

AVEZ-VOUS MAL À L'ÉPAULE?

Participer à un projet de recherche en physiothérapie pour évaluer l'effet des exercices contrôle neuromusculaire pour les épaules d'une durée de 6 semaines.

Les personnes recherchées :

- membres des Forces
- homme et femme
- âgé de 18 ans et plus
- qui présentent des douleurs musculaires et/ou articulaires à l'épaule
- qui ne présentent pas d'engourdissements, de picotements, ou de sensation de "choc électrique" aux membres supérieurs
- Qui n'ont jamais eu un épisode de luxation (débarquement) à l'épaule
- Qui sont disponibles pour une durée de 6 semaines.

Pour plus d'informations, SVP contactez:

Amanda Ager, pht (amanda.ager.1@ulaval.ca)

ou Valérie Charbonneau, pht 418-844-5000 poste 5783

Responsables du projet : Luc J. Hébert, pht, PhD, CD, Jean-Sébastien Roy, pht, PhD,

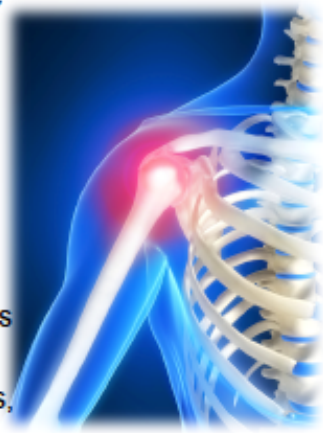
Amanda Ager, pht amanda.ager.1@ulaval.ca Physio: poste 5783

APPENDIX B: Recruitment poster for the military clinicians, Valcartier Garrision, Quebec

PROJET: EFFICACITÉ D'UN PROGRAMME DE RENFORCEMENT ET DE CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR SUR LA FONCTION DE L'ÉPAULE DE PERSONNES AYANT UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS: UN ESSAI CLINIQUE RANDOMISÉ.

NOUS CHERCHONS DES PARTICIPANTS AVEC UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS À L'ÉPAULE POUR UN PROJET DE RECHERCHE

Le projet : Participer à un programme de renforcement et de contrôle neuromusculaire pour les membres supérieurs d'une durée de 6 semaines.



Les personnes recherchées :

- homme et femme
- âgés de 18 ans et plus
- qui présentent des douleurs musculaires et/ou articulaires à l'épaule
- qui ne présente pas d'engourdissements, de picotements, ou de sensation de 'choc électrique' aux membres supérieurs

Si vous avez des patients intéressés: Remplissez le formulaire **ADMIN-250** (référence en physio) et indiquez clairement leur intérêt à participer au projet et leur numéro de téléphone. Le patient sera par la suite contacté par l'évaluateur (physiothérapeute) afin de vérifier les critères d'inclusions.

Pour plus d'informations, SVP contactez:

France Gamache, pht

418-844-5000 poste 5783 / france.gamache@forces.gc.ca

Responsables du projet : Luc J. Hébert, pht, PhD, CD, Jean-Sébastien Roy, pht, PhD, Amanda Ager, pht et France Gamache, pht.

Projet de recherche approuvé par le Comité d'éthique à la recherche du CIRRIS. # d'éthique : 2015-446

APPENDIX C: Information package for participants

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Québec

IRDPQ
INSTITUT UNIVERSITAIRE DE RÉADAPTATION

Feuillet d'information et Formulaire de consentement
pour un projet de recherche
Guide pour la rédaction

Efficacité d'un programme de renforcement et de contrôle neuromusculaire des membres supérieurs sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: un essai clinique randomisé

Responsable: Amanda Ager, pht, candidate à la maîtrise
France Garnache, pht
Jean-Sébastien Roy, pht, Ph.D.
Maj Luc J. Hébert, pht, Ph.D., CD

Collaborateurs: LCol Peter Rowe, pht, MSc
Maj Anny Fredette, pht
Capt Nathalie Royer, pht

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Québec

Feuillet d'information

1

Numéro de projet : 2015-446
(Réservé à l'administration)

I. Titre du projet :

Efficacité d'un programme de renforcement et de contrôle neuromusculaire des membres supérieurs sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: Un essai clinique randomisé.

II. Responsables et collaborateurs:

Responsables: Amanda Ager, pht, candidate à la maîtrise
France Gamache, pht
Jean-Sébastien Roy, pht, Ph.D.
Maj Luc J. Hébert, pht, Ph.D., CD

Collaborateurs: LCol Peter Rowe, pht. MSc
Maj Anny Fredette, pht
Capt Nathalie Royer, pht
Sophie Bernard, pht
Pierre-Marc Vézina, pht
Myriam Cyr, pht
Valérie Charbonneau, pht
Marie-Élise Prémont, pht

III. Organisme de subvention :

Aucun

IV. Introduction :

Nous vous invitons à participer à un projet de recherche ayant pour objectif de vérifier l'efficacité d'un nouveau programme de renforcement et de contrôle neuromusculaire pour les membres supérieurs. Avec ce programme, nous visons à réduire la douleur et améliorer la fonction de l'épaules à l'aide de traitements actifs en physiothérapie.

Cependant, avant d'accepter de participer à ce projet de recherche, veuillez prendre le temps de lire, comprendre et considérer attentivement les renseignements qui suivent.

Ce formulaire d'information et de consentement vous explique le but de ce projet de recherche, il vous en présente les procédures, les avantages, les risques et les inconvénients, de même que les personnes avec qui communiquer au besoin.

Le formulaire d'information et de consentement peut contenir des mots que vous ne comprenez pas. Nous vous invitons à poser toutes les questions que vous jugerez utiles aux chercheurs responsables du projet et aux autres membres du personnel affectés au projet de recherche, et à demander des explications sur tout mot ou renseignement qui n'est pas clair.

V. Nature et objectifs du projet :

Le projet va se déroulé au Garnison Valcartier avec les membres militaires qui souffrent d'une tendinopathie de la coiffe des rotateurs à l'épaule. Le mot tendinopathie est un terme très large utilisé pour décrire la présence d'une inflammation et de dégénérescence sur la portion d'un muscle qui s'attache sur l'os et que l'on appelle un tendon. À l'épaule, il y a, entre autres, 4

muscles dont les tendons sont regroupés et que l'on s'appelle la coiffe des rotateurs et ces muscles sont responsables de maintenir votre épaule stable et solide lors de gestes de tous les jours. Une tendinopathie de la coiffe des rotateurs peut provoquer des douleurs, un manque de force important et une diminution de contrôle de votre épaule lors d'activités de la vie quotidienne et surtout dans vos activités de travail comme militaire.

En acceptant de participer à cette étude, vous devrez, pour une durée de 6 semaines, participer à des interventions en physiothérapie. Nous allons comparer 2 types d'approche en physiothérapie pour la réadaptation d'un tendinopathie de la coiffe des rotateurs à l'épaule. Vous allez prendre part à des exercices actifs pour l'épaule, soit dans le groupe expérimental ou le group conventionnel. Vous devrez également participer à 2 séances d'évaluation à la clinique de physiothérapie du Centre de Santé Valcartier (CSV).

Si vous faites partie du groupe expérimental vous allez recevoir un suivi à la clinique de physiothérapie (30 minutes par semaine) et participer au programme d'exercices 3 fois par semaine pour une durés d'environ 35-45 minutes à chaque session. Vous allez aussi recevoir quelques exercices à faire à la maison.

Si vous faites partie du groupe conventionnel vous allez recevoir des traitements de physiothérapie 2 fois par semaine à la clinique de physiothérapie avec un physiothérapeute et vous aurez aussi à faire quelques exercices à la maison.

Vous serez placé dans un des deux groupes de façon aléatoire. C'est très important de ne pas mentionner à qui que ce soit dans quel groupe vous avez été placé ni de vos traitements en physiothérapie. Votre confidentialité aura un impact important sur les résultats de notre projet.

Les résultats de cette étude nous aideront à mieux orienter les traitements chez les militaires et à offrir des soins basés sur la recherche. Cela nous aidera également à offrir une meilleur qualité de soins en réadaptation sur toutes les bases des FAC à travers le Canada et outre-mer.

VI. Déroulement du projet :

Vous prendrez part à 2 sessions d'évaluation au département de physiothérapie par un physiothérapeute. Vous allez ensuite participer à vos traitements en physiothérapie pendant 6 semaines. Par la suite, vous allez compléter des questionnaires de douleur 3 et 6 mois après vos traitements. Prenez note que toutes les évaluations et interventions se feront au département de physiothérapie au Centre de Santé de la Garnison Valcartier.

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Québec

Feuillet d'information

3

Numéro de projet : 2015-446

(Réservé à l'administration)

Partie 1 Évaluation initiale ≈ 2h	Partie 2 Intervention de réadaptation ≈ 4.5h par semaines (pour 6 semaines)	Partie 3 Évaluation post-intervention ≈ 2h	Partie 4 Suivi à 3 mois ≈ 20 minutes
- Critères d'admissibilité - Questionnaires de douleur -Évaluation de mouvements fonctionnels aux épaules -Évaluation clinique de l'épaule -Évaluation de force en rotation externe et abduction aux épaules	**GROUPE EXPÉRIMENTAL** -Suivi en physio (30 minutes) -Programme de renforcement et contrôle moteur de l'épaule (35-45 min, 3 fois par semaine) et exercices à domicile (3 séries de 15 répétitions, 3-5 fois par semaine, selon tolérance) **GROUPE CONVENTIONNEL** -Suivi en physio (30 mins, 2 fois par semaine) et exercices à domicile (3 séries de 15 répétitions, 3-5 fois par semaine, selon tolérance)	- Questionnaires de douleur -Évaluation push-up -Évaluation sacs de sable -Évaluation de mouvements fonctionnels aux épaules -Évaluation de force en rotation externe et abduction aux épaules	Questionnaires de douleur

Partie 1 : L'étude débutera par une rencontre avec le responsable du projet au département de physiothérapie au CSV, Garnison Valcartier, qui vous questionnera pour vérifier votre admissibilité à l'étude. Si ces questions démontrent que vous présentez une tendinopathie de la coiffe des rotateurs, vous serez admis dans l'étude. Lors de cette même rencontre, si vous êtes admis à l'étude, nous procéderons à différentes mesures en lien avec vos épaules. Vous aurez à répondre à un questionnaire sur vos douleurs nommé le WORC (Western Ontario Rotator Cuff Index) et le DASH (Disability of the Arm, Shoulder, Hand) et à compléter quelques échelles visuelles analogues pour mesurer l'intensité de vos douleurs à l'épaule. Ensuite, vous allez participer à quelques épreuves physiques, par exemple, une évaluation de force et des mouvements actifs aux épaules. Vous allez compléter chacune de ces épreuves avec la meilleure performance possible. Cette session d'évaluation aura une durée approximative de 2 heures.

À la fin de la session d'évaluation initiale, vous serez assigné de façon aléatoire soit au groupe expérimental ou au groupe conventionnel en physiothérapie.

Partie 2: Vous aurez à participer à plusieurs sessions de physiothérapie par semaine.

Feuillet d'information

2015-446

Numéro de projet : _____
(Réservé à l'administration)

Si vous êtes avec **le groupe expérimental**, vous allez participer à un programme d'exercices de 6 semaines, à 3 sessions de 35-45 minutes par semaine. Le programme d'exercices comprend 12 stations d'exercices différentes, avec différentes progressions selon vos capacités et douleurs. Vous pouvez prendre des repos de maximum 1-2 minutes entre chaque station au besoin. Vous allez aussi à faire des exercices à la maison. Les exercices à la maison vont être donner par la physiothérapeute; par exemple 3 exercices à faire de 3 séries de 15 répétitions (3-5 fois par semaines), aussi selon votre tolérance. Au total, vous allez avoir approximativement 4.5 heures d'exercices et de traitement par semaine.

Si vous êtes avec **le groupe conventionnel**, vous allez avoir, par semaine, 2 séances de suivis en physiothérapie de 30 minutes chacune, pour 6 semaines. Vous allez avoir également des exercices à faire à la maison. Les exercices à la maison vont être donner par la physiothérapeute; par exemple 3 exercices à faire de 3 séries de 15 répétitions (3-5 fois par semaines), selon votre tolérance. En gros, vous allez avoir approximativement 4.5 heures d'exercices et de traitement par semaine.

Vous pourrez continuer vos entrainements de course à pied et autres activités impliquant les membres inférieurs selon les recommandations du physiothérapeute, en autant que l'activité se pratique sans aggravation de vos symptômes aux épaules. Pendant la durée de l'étude, vous devrez inscrire vos entrainements dans un journal de bord qui sera supervisé par le physiothérapeute traitant.

Partie 3: Dans la semaine suivant la fin de l'entrainement supervisé, les évaluations effectuées lors de la Partie 1 seront refaites à nouveau. La durée de cette deuxième session d'évaluation sera aussi d'environ 2 heures.

Partie 4 : Trois mois et six mois après avoir complété l'intervention en réadaptation, vous devrez remplir à nouveau les questionnaires de symptômes et de fonction afin de vérifier la durabilité des effets de l'intervention qui vous a été assignée. Ceci prendra environ 20 minutes.

VII. Risques potentiels et inconvénients personnels :

Risques potentiels :
Les risques inhérents à cette étude correspondent aux risques normaux engendrés par une évaluation et une intervention en physiothérapie, c'est-à-dire une augmentation temporaire de douleur (24 à 48 heures). Des tests semblables à ceux effectués dans cette étude ont déjà été exécutés chez des personnes ayant la même atteinte que vous sans qu'il y ait eu détérioration de leur état. Si les évaluations et/ou les interventions augmentent vos symptômes, vous aurez toujours accès au soins offert au CSV et au département de physiothérapie. Nous vous demandons simplement de nous garder bien informés si cela était le cas.

Un malaise temporaire à la suite des tests ou des séances d'entrainement demeure toujours possible. Si tel est le cas, il faudra nous aviser et l'intervention sera réajustée.

Inconvénients :
Vous aurez à vous déplacer 2-3 fois par semaine vers la clinique de physiothérapie au CVS sur la base militaire pour recevoir vos traitements. Au besoin, une lettre pourra être fournie pour expliquer/justifier votre participation au projet à votre chaîne de commandement. Vous allez également recevoir des restrictions médicales temporaires au besoin pour la durée du projet (6 semaines) afin d'éviter d'aggraver votre condition lors des tâches militaires et d'entrainements physiques.

Ces sessions vous seront dispensées gratuitement toutefois, aucun frais de déplacement ne sera couvert.

Feuillet d'information

Numéro de projet : 2015-446

(Réservé à l'administration)

VIII. Avantages possibles :
En acceptant de participer à cette étude, vous bénéficierez d'interventions réalisées par un physiothérapeute spécialisé en réadaptation des épaules. Toutes les interventions faisant partie de l'étude ont démontré des bénéfices cliniques. Ainsi, l'intervention qui vous sera assignée représente un potentiel d'amélioration de votre condition. Finalement, votre participation contribuera à faire avancer les recherches sur les interventions en physiothérapie avec des personnes souffrant d'une tendinopathie de la coiffe des rotateurs.

IX. Participation volontaire et retrait de la participation :
Votre participation à ce projet de recherche est volontaire. Vous êtes donc libre de refuser d'y participer. Vous pouvez également vous retirer de ce projet à n'importe quel moment, sans avoir à donner de raisons, en faisant connaître votre décision au chercheur responsable du projet ou à l'un des membres du personnel affectés au projet. Votre décision de ne pas participer à ce projet de recherche ou de vous retirer n'aura aucune conséquence sur la qualité des soins et des services auxquels vous avez droit ni sur votre relation avec le chercheur responsable du projet et les autres intervenants. Les responsables pourront également mettre fin à votre participation si vous ne répondez plus aux critères d'admissibilité. Si votre participation n'est plus requise pour l'étude, vous serez informé des raisons qui justifient cette décision.

X. Clause de responsabilité :
En acceptant de participer à cette étude, vous ne renoncez à aucun de vos droits ni ne libérez les chercheurs, le commanditaire ou les institutions impliquées de leurs obligations légales et professionnelles.

XI. Indemnité compensatoire :
Aucune rémunération n'est rattachée à votre participation.

XII. Confidentialité, conservation et utilisation des résultats :
Les chercheurs et leur équipe respecteront la confidentialité dans les limites permises par la loi. Les résultats des tests et les informations recueillies demeureront confidentiels et ne seront accessibles qu'à l'équipe de chercheurs ou encore aux représentants du Comité d'éthique à la recherche à des fins de gestion ou de vérification du bon déroulement de la recherche. Avant le processus d'analyse des résultats, votre nom sera remplacé par un code qui vous assurera l'anonymat. La liste des numéros et des noms correspondants sera conservée dans un classeur verrouillé dans le bureau d'un des chercheurs. Ainsi, les données seront dénominalisées et, de ce fait, toute publication scientifique découlant de cette étude respectera la confidentialité. Toutes les données seront conservées 5 ans après la fin du projet et détruites par la suite.

À des fins de surveillance et de contrôle, votre dossier de recherche ainsi que vos dossiers médicaux, s'il y a lieu, pourront être consultés par une personne mandatée par le Comité d'éthique de la recherche de l'IRDPQ, ou par toute autre personne dument mandatée pour vérifier la gestion ou le bon déroulement de la recherche.

XIII. Questions sur le projet et personnes-ressources :
Vous pourrez joindre **Amanda Ager pht (amanda.ager.1@ulaval.ca) (contacte principale)**, France Garnache, pht (france.garnache@forces.gc.ca, au département de physiothérapie 418-

844-5000 poste 5783) ou Maj / Dr Luc J. Hébert, phf, C.D. (418 529-9141 poste 6579) durant les heures ouvrables si vous avez des questions relatives à l'étude ou si votre condition se détériore à la suite des évaluations. Nous pourrons joindre votre médecin traitant si vous le désirez.

Si vous avez des questions d'ordre éthique, vous pouvez communiquer avec la coordonnatrice du comité d'éthique de la recherche de l'IRDPQ au 418 529-9141, poste 2888 ou coordonnatrice.cer@irdpq.qc.ca. Les frais d'interurbain seront remboursés sur présentation d'une pièce justificative, le cas échéant. Dans l'éventualité où vous désiriez formuler une plainte, vous pourrez vous adresser à la commissaire aux plaintes et à la qualité des services de l'IRDPQ à l'adresse courriel suivante : plaintes@irdpq.qc.ca ou par téléphone au 418 529-9141, poste 6247 (téléscripteur ATS : 418 649-3734).

APPENDIX D: Consent form for participants

Centre intégré universitaire de santé et de services sociaux de la Capitale Nationale
Québec

Guide pour la rédaction – Projet

Titre du projet : Efficacité d'un programme de renforcement et de contrôle neuromusculaire du membre supérieur sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: Un essai clinique randomisé.

Chercheur responsable du projet : Amanda Ager, pht, candidate à la maîtrise
France Gamache, pht
Jean-Sébastien Roy, pht, Ph.D.
Maj Luc J. Hébert, pht, Ph.D., CD

1) Le(la) responsable m'a informé(e) de la nature et des buts de ce projet de recherche ainsi que de son déroulement;
2) Le(la) responsable m'a informé(e) des risques et inconvénients associés à ma participation;
3) Ma participation à cette étude est volontaire et je peux me retirer en tout temps sans préjudice;
4) Les données de cette étude seront traitées en toute confidentialité et elles ne seront utilisées qu'aux fins scientifiques et par les partenaires identifiés au formulaire d'information;
5) J'ai pu poser toutes les questions voulues concernant ce projet et j'ai obtenu des réponses satisfaisantes;
6) Ma décision de participer à cette étude ne libère ni les chercheurs, ni l'établissement hôte de leurs obligations envers moi;
7) Je sais qu'aucune rémunération n'est rattachée à ma participation;
8) Le(la) responsable m'a remis un exemplaire du feuillet d'information et du formulaire de consentement;
9) J'ai lu le présent formulaire et je consens volontairement à participer à cette étude;
10) Je désire recevoir une copie des résultats de l'étude ☐ oui ☐ non
(Courriel: _____)
11) J'accepte d'être recontacté(e) pour d'autres projets menés par les chercheurs de ce projet ☐ oui ☐ non

Nom du participant	Date de naissance	Numéro de téléphone
Signature du participant *	Date	
Nom du chercheur	Date	Signature

APPENDIX E: Subjective telephone interview evaluation form

Projet de recherche # 2015-446

NUMÉRO D'INDENTIFICATION : _____

DATE DE L'ÉVALUATION (JOUR/MOIS/ANNÉE) : ____/____/____.

CRITÈRES D'ÉLIGIBILITÉ – ÉVALUATION TÉLÉPHONIQUE PAR L'ÉVALUATEUR

ÉTUDE : EFFICACITÉ D'UN PROGRAMME DE RENFORCEMENT ET DE CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR SUR LA FONCTION DE L'ÉPAULE DE PERSONNES AYANT UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS: UN ESSAI CLINIQUE RANDOMISÉ.

CONSENTEMENT VERBALE POUR LES QUESTIONS MÉDICALES SUIVANTES: _____ (INTIAL)

Nom:_____ **Numéro de contact:** _____

Sexe: Homme / Femme **Age:** _____ **Fumeur: OUI / NON**

Métier: _____ **Années de service:** _____

Histoire de la blessure: _____

_____

_____

_____

Durée des symptômes :_____ **(en mois)**

Dominance: GAUCHE / DROIT

1. CRITÈRES D'INCLUSION		
1.1 Avez-vous de la douleur locale à l'épaule? GAUCHE / DROIT	**Oui**	**Non**
1.2 Avez-vous de la douleur à l'épaule lorsque vous travaillez les bras en élévation (au-dessus la tête)?	**Oui**	**Non**
1.3 Ressentez-vous une sensation de faiblesse à l'épaule du côté atteint?	**Oui**	**Non**
1.4 Êtes-vous âgé entre 18 et 60 ans?	**Oui**	**Non**

2. CRITÈRES D'EXCLUSION		
2.1 Douleur à une de vos épaules qui est reproduite lors de mouvements actifs ou passifs du cou/tête?	**Oui**	**Non**
2.2 Traumatisme important à l'épaule? (luxation traumatique, fracture) **2.2.1 Si oui, laquelle/lesquelles?**	**Oui**	**Non**
2.3 Épisodes de luxation, ou un sensation que l'épaule va "débarquer"?	**Oui**	**Non**

2.4 Traumatisme importante au bras? (main, poignet, coude) **2.4.1 Si Oui, laquelle/lesquelles?**	**Oui**	**Non**
2.5 Signes ou symptômes de picotements ou choque électriques au cou ou au membres supérieurs?	**Oui**	**Non**

3. CONDITION DE SANTÉ GÉNÉRALE		
3.1 Avez-vous une ou plusieurs des conditions suivantes?		
3.1.1 Problème cardiaque	**Oui**	**Non**
3.1.2 Problème pulmonaire chronique/asthme	**Oui**	**Non**
3.1.3 Hypertension artérielle	**Oui**	**Non**
3.1.4 Diabète	**Oui**	**Non**
3.1.5 Problème rénal	**Oui**	**Non**
3.1.6 Problème neurologique	**Oui**	**Non**
3.1.7 Cancer	**Oui**	**Non**
3.1.8 Maladie rhumatoïde, inflammatoire, dégénérative ou neurologique	**Oui**	**Non**
3.1.9 Maux de têtes ou migraines non-contrôlés	**Oui**	**Non**

4. ANTÉCÉDENTS CHIRURGICAUX		
4.1 Avez-vous déjà subi une chirurgie à une articulation du membre supérieur (bras, main, cou, dos)?	**Oui**	**Non**
4.1.1 Si Oui, laquelle/lesquelles? : _____		
5. MÉDICATION		
5.1 Actuellement prenez-vous des médicaments?	**Oui**	**Non**
5.1.1 Si Oui, lequel/lesquels et pour quelle(s) raison(s)? :		

Avez-vous d'autres symptômes ou raison pour lesquels vous ne devriez pas participer à ce projet de recherche ?

OUI / NON

Si OUI : _____

PARTICIPANT: INCLUS / EXCLUS

ÉVALUATEUR : _____ **DATE:** _____

APPENDIX F: Objective physical evaluation form (Baseline)

Projet de recherche # 2015-446

NUMÉRO D'INDENTIFICATION : _____

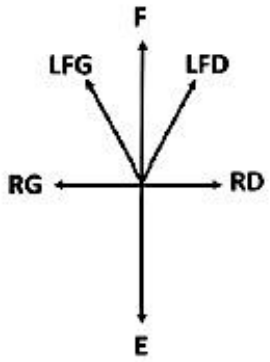
INFORMATIONS GÉNÉRALES – ÉVALUATION INITIALE PAR L'ÉVALUATEUR

ÉTUDE : EFFICACITÉ D'UN PROGRAMME DE RENFORCEMENT ET DE CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR SUR LA FONCTION DE L'ÉPAULE DE PERSONNES AYANT UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS: UN ESSAI CLINIQUE RANDOMISÉ.

1. DONNÉES SOCIODÉMOGRAPHIQUES ET ANTHROPOMÉTRIQUES		
1.1 Sexe	Féminin	Masculin
1.2 Date de naissance (jj/mm/aa)	Âge: _____	_____
1.3 Taille (m)	__, ____	
1.4 Poids (kg)	____,__	
1.5 Distance acromion-3e doigt (cm)	____,__	
1.6 Épaule atteinte	DROITE	GAUCHE
1.7 Dominance (Edinburgh Handedness Inventory)	DROITE	GAUCHE

ÉVALUATION OBJECTIVE

AMPLITUDE ACTIVE AU COU : (Douleur 1-10)



Évaluateur : _____ Date : _____ 1

NUMÉRO D'IDENTIFICATION : _____

1. ARCHE DOULOUREUSE:_____

2. TEST D'ABUTTEMENT

TEST	+VE	-VE
NEERS		
HAWKIN'S KENNEDY		

3. TEST DE LA COIFFE DES ROTATEURS

TEST	+VE	-VE
DOULEUR EN ROTATION EXTERNE RESISTEE (0°ABD)		
DOULEUR EN ABDUCTION RÉSISTÉE (45° ABD)		
EMPTY CAN TEST		
FULL CAN TEST		

DOULEUR ÉPAULE ATTEINTE: _____/10

AUTRES TESTS (AU BESOIN)

TESTS SPÉCIAUX:(INSTABILITÉ)

TEST	+VE	-VE
LOAD AND SHIFT TEST		
CRANK TEST		
APPREHENSION TEST		
DROP ARM TEST		

TEST SPÉCIAUX (COU ET MOBILITÉ NEURALE)

TEST	+VE	-VE
SPURLINGS TEST		
ULNT MÉDIAN		

AUTRE: _____

_____

_____

_____

_____

DIAGNOSTIQUE CLINIQUE: _____

Évaluateur : _____ Date :_____ 2

NUMÉRO D'IDENTIFICATION : _____

AMPLITUDE ACTIVE / PASSIF À L'ÉPAULE (Douleur = 0-10) (Note : C = complète)

MOVEMENT ACTIF DEBOUT	DROIT (A/P)	GAUCHE (A/P)
FLEXION		
ABDUCTION		
ROTATION EXTERNE (90° ABD)		
ROTATION INTERNE (90° ABD)		

DOULEUR ÉPAULE ATTEINT AVANT MESURES DE FORCE: _____/10

FORCE ISOMÉTRIQUE DE L'ÉPAULE		
ROTATION EXTERNE (À 0° ABD)	**DROITE**	**GAUCHE**
ESSAI 1 (NEWTONS)		
ESSAI 2 (NEWTONS)		
ESSAI 3 (NEWTONS) (si > 10% de différence)		
Moyenne des essais (NEWTONS)		
ABDUCTION (À 0° ABD)	**DROITE**	**GAUCHE**
ESSAI 1 (NEWTONS)		
ESSAI 2 (NEWTONS)		
ESSAI 3 (NEWTONS) (si > 10% de différence)		
MOYENNE DES ESSAIS (NEWTONS)		

DOULEUR ÉPAULE ATTEINTE APRÈS MESURES DE FORCE: _____/10

Bras de levier (ABDUCTION) _____(cm)
Bord distale acromion - centre du pad (supérior au épicondyle latéral)

Bras de levier (ROTATION EXTERNE) _____(cm)

Évaluateur : _____ Date : _____ 3

Bord distale acromion - centre du pad (supérior au processus styloïde)

QUESTIONNAIRE DASH:
MODULE GLOBAL: _____ MODULE TRAVAIL: _____ MODULE SPORT:_____
TOTAL: _____

QUESTIONNAIRE WORC:
MODULE SYMPTÔMES PHYSIQUES:_____ MODULE SPORT / LOISIRS:_____
MODULE TRAVAIL:_____ MODULE STYLE DE VIE:_____ MODULE ÉMOTIONS:_____ **TOTAL:** _____

Évaluateur : _____ Date :_____ 4

Projet: Efficacité d'un programme de renforcement et de contrôle neuromusculaire des membres supérieurs sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: essai clinique randomisé (Ager et al. 2015) Approbation du CÉR 2015-446

NUMÉRO D'INDENTIFICATION : _____

DATE DE L'ÉVALUATION (JOUR/MOIS/ANNÉE) : ____/____/____

FEUILLE DE ROUTE - RENCONTRE INITIALE

A. PRÉPARATION AVANT L'ARRIVÉE DU SUJET

1. Préparer tous les documents papiers :
   - Formulaire de consentement; _____
   - Questionnaire DASH; _____
   - Questionnaire WORC; _____
   - Questionnaire Edinburgh Handedness; _____
   - Critères d'éligibilité objectives; _____
   - Ordre de déroulement des procédures d'évaluation; _____
2. Préparer le matériel pour la rencontre :
   - **lit électrique** _____
   - **Inclinomètre** _____
   - **dynamomètre + sangles** _____
   - **gallon** _____
   - **balance** _____
   - **ruban adhésif** _____
   - **sac de sable (évaluation de 6 semaine)** _____

B. ACCUEIL ET ÉVALUATION DU SUJET

3. Accueil du sujet : expliquer le déroulement de la rencontre et répondre aux questions; _____
4. Vérifier le formulaire de consentement, DASH, WORC, Handedness Invenvory _____
5. Évaluer les critères d'éligibilité; _____
6. Peser et mesurer le sujet _____
7. Mesure d'amplitude articulaire bilat (flexion, RE, RI, abduction) _____
8. Mesures de force bilat (rotation externe à 90 d'abduction, abduction) _____
9. Expliquer la randomisation et les suivis pendant 6 semaines _____
10. Questions et remercier du participant _____

APPENDIX G: Objective physical evaluation form (6-week follow up)

Projet de recherche # 2015-446

NUMÉRO D'INDENTIFICATION : _____

INFORMATIONS GÉNÉRALES – ÉVALUATION FINALE PAR L'ÉVALUATEUR

ÉTUDE : EFFICACITÉ D'UN PROGRAMME DE RENFORCEMENT ET DE CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR SUR LA FONCTION DE L'ÉPAULE DE PERSONNES AYANT UNE TENDINOPATHIE DE LA COIFFE DES ROTATEURS: UN ESSAI CLINIQUE RANDOMISÉ.

1. DONNÉES SOCIODÉMOGRAPHIQUES ET ANTHROPOMÉTRIQUES		
1.1 Épaule atteinte	DROITE	GAUCHE

AMPLITUDE ACTIVE / PASSIF À L'ÉPAULE (Douleur = 0-10)

MOVEMENT ACTIF DEBOUT	DROIT (A/P)	GAUCHE (A/P)
FLEXION		
ABDUCTION		
ROTATION EXTERNE (90° ABD)		
ROTATION INTERNE (90° ABD)		

QUESTIONNAIRE GROC:
CHANGEMENT NOTÉ (1-3): _____ **NIVEAU DE CHANGEMENT (1 à 7 ou -1 à -7)** _____

QUESTIONNAIRE DASH:
MODULE GLOBAL: _____ MODULE TRAVAIL: _____ MODULE SPORT:_____ **TOTAL:** _____

QUESTIONNAIRE WORC:
MODULE SYMPTÔMES PHYSIQUES:_____ MODULE SPORT / LOISIRS:_____
MODULE TRAVAIL:_____ MODULE STYLE DE VIE:_____ MODULE ÉMOTIONS:_____
TOTAL: _____

Évaluateur : _____ Date :_____ 1

NUMÉRO D'INDENTIFICATION : _____

DOULEUR ÉPAULE ATTEINT AVANT MESURES DE FORCE: _____/10

FORCE ISOMÉTRIQUE DE L'ÉPAULE		
ROTATION EXTERNE (À 0° ABD)	**DROITE**	**GAUCHE**
ESSAI 1 (NEWTONS)		
ESSAI 2 (NEWTONS)		
ESSAI 3 (NEWTONS) (si > 10% de différence)		
Moyenne des essais (NEWTONS)		
ABDUCTION (À 0° ABD)	**DROITE**	**GAUCHE**
ESSAI 1 (NEWTONS)		
ESSAI 2 (NEWTONS)		
ESSAI 3 (NEWTONS) (si > 10% de différence)		
MOYENNE DES ESSAIS (NEWTONS)		

DOULEUR ÉPAULE ATTEINTE APRÈS MESURES DE FORCE: _____/10

STATION SAC DE SABLE:
30 lever en 3 minutes 30 seconds

Passer: OUI / NON / NON-TENTÉ

Temps: _____

Nombre de répétition: _____

Évaluateur : _____ Date : _____ 2

APPENDIX H: DASH questionnaire (French Canadian)

QUESTIONNAIRE DASH SUR LES INCAPACITÉS RELIÉES À UNE ATTEINTE AUX MEMBRES SUPÉRIEURS

Évaluez votre capacité à faire les activités suivantes au cours de la dernière semaine en encerclant le numéro dans la colonne appropriée. Répondez en vous basant sur votre capacité à réaliser la tâche sans vous soucier de comment vous l'effectuez ou de quelle main vous utilisez pour réaliser l'activité.

	Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1. Ouvrir un pot neuf ou fermé serré.	1	2	3	4	5
2. Écrire.	1	2	3	4	5
3. Tourner une clé.	1	2	3	4	5
4. Préparer un repas.	1	2	3	4	5
5. Ouvrir une porte lourde en poussant.	1	2	3	4	5
6. Placer un objet sur une tablette située au-dessus de votre tête.	1	2	3	4	5
7. Faire de gros travaux ménagers (ex.: laver les murs, laver les planchers).	1	2	3	4	5
8. Jardiner ou faire l'entretien d'un terrain.	1	2	3	4	5
9. Faire un lit.	1	2	3	4	5
10. Transporter un sac d'épicerie ou un porte-document (valise).	1	2	3	4	5
11. Transporter un objet lourd (plus de 10 livres).	1	2	3	4	5
12. Changer une ampoule située au-dessus de votre tête.	1	2	3	4	5
13. Laver vos cheveux ou sécher vos cheveux à l'aide d'un séchoir	1	2	3	4	5
14. Laver votre dos.	1	2	3	4	5
15. Mettre un chandail.	1	2	3	4	5
16. Utiliser un couteau pour couper des aliments.	1	2	3	4	5
17. Activités de loisirs qui exigent peu d'effort (ex.: jouer aux cartes, etc.).	1	2	3	4	5
18. Activités de loisirs dans lesquelles votre bras, votre épaule ou votre main subit un impact (ex.: golf, utiliser un marteau, tennis, etc.).	1	2	3	4	5
19. Activités de loisirs durant lesquelles vous bougez votre bras librement (ex.: jouer au frisbee, au badminton, etc.).	1	2	3	4	5
20. Déplacements (transports).	1	2	3	4	5
21. Activités sexuelles.	1	2	3	4	5

QUESTIONNAIRE DASH SUR LES INCAPACITÉS RELIÉES À UNE ATTEINTE AUX MEMBRES SUPÉRIEURS

	Pas du tout	Un peu	Moyennement	Beaucoup	Extrêmement
22. Au cours de la dernière semaine, dans quelle mesure votre problème au bras, à l'épaule ou à la main a-t-il nui à vos activités sociales habituelles avec votre famille, amis, voisins ou groupes? (encerclez un chiffre)	1	2	3	4	5

	Pas limité du tout	Légèrement limité	Moyennement limité	Très limité	Incapable
23. Au cours de la dernière semaine, avez-vous été limité dans votre travail ou dans vos autres activités habituelles à cause de votre problème au bras, à l'épaule ou à la main? (encerclez un chiffre)	1	2	3	4	5

Évaluez la sévérité des symptômes suivants au cours de la dernière semaine. (encerclez un chiffre)

	Aucune	Légère	Modérée	Sévère	Extrême
24. Douleur au bras, à l'épaule ou à la main.	1	2	3	4	5
25. Douleur au bras, à l'épaule ou à la main lorsque vous réalisez toute activité spécifique.	1	2	3	4	5
26. Picotements (fourmillements) au bras, à l'épaule ou à la main.	1	2	3	4	5
27. Faiblesse au bras, à l'épaule ou à la main.	1	2	3	4	5
28. Raideurs (manque de souplesse) au bras, à l'épaule ou à la main.	1	2	3	4	5

	Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Tellement de difficulté que je ne peux pas dormir
29. Au cours de la dernière semaine, dans quelle mesure avez-vous eu de la difficulté à dormir à cause de votre douleur au bras, à l'épaule ou à la main? (encerclez un chiffre)	1	2	3	4	5

	Fortement en désaccord	En désaccord	Ni d'accord ni en désaccord	En accord	Fortement en accord
30. Dans quelle mesure êtes-vous d'accord avec la phrase suivante : « Je me sens moins capable, moins confiant ou moins utile à cause de mon problème au bras, à l'épaule ou à la main ».	1	2	3	4	5

COTATION DU DASH INCAPACITÉ/SYMPTÔME = $\left(\left[\frac{\text{somme des valeurs choisies}}{\text{nombre de questions répondues}}\right] - 1\right) \times 25$

Un score du DASH ne peut pas être calculé s'il y a plus que 3 réponses manquantes.

QUESTIONNAIRE DASH SUR LES INCAPACITÉS RELIÉES À UNE ATTEINTE AUX MEMBRES SUPÉRIEURS

MODULE TRAVAIL (OPTIONNEL)

Les questions suivantes portent sur l'impact de votre problème au bras, à l'épaule ou à la main sur votre capacité à travailler (incluant « tenir maison » si cela est votre principale occupation).

Indiquez quel est votre travail même si votre problème au bras, à l'épaule ou à la main vous empêche de le réaliser actuellement : _____

❑ Je n'ai pas de travail. (Ne répondez pas à cette section.)

Encerclez le numéro qui décrit le mieux votre capacité physique au cours de la dernière semaine. Si vous n'avez pas eu l'occasion de réaliser votre travail au cours de la dernière semaine, faites de votre mieux pour choisir la réponse qui serait la plus juste. Avez-vous eu de la difficulté à :

	Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1. utiliser la même technique de travail que d'habitude?	1	2	3	4	5
2. faire votre travail habituel à cause de votre douleur au bras, à l'épaule ou à la main?	1	2	3	4	5
3. faire votre travail aussi bien que vous l'auriez voulu?	1	2	3	4	5
4. passer le même nombre d'heures que d'habitude à réaliser votre travail?	1	2	3	4	5

MODULE SPORTS/MUSIQUE (OPTIONNEL)

Les questions suivantes portent sur l'impact de votre problème au bras, à l'épaule ou à la main sur la pratique d'un instrument de musique, d'un sport ou des deux. Si vous pratiquez plus d'un sport ou d'un instrument (ou les deux), répondez en considérant l'activité qui est la plus importante pour vous.

Indiquez le sport ou l'instrument qui est le plus important pour vous peu importe si votre problème au bras, à l'épaule ou à la main vous empêche de le réaliser actuellement : _____

❑ Je ne pratique pas un sport ou un instrument. (Ne répondez pas à cette section.)

Encerclez le numéro qui décrit le mieux votre capacité physique au cours de la dernière semaine. Si vous n'avez pas eu l'occasion de réaliser cette activité au cours de la dernière semaine, faites de votre mieux pour choisir la réponse qui serait la plus juste. Avez-vous eu de la difficulté à :

	Pas de difficulté	Difficulté légère	Difficulté moyenne	Difficulté sévère	Incapable
1. utiliser la même technique que d'habitude pour pratiquer votre instrument ou sport?	1	2	3	4	5
2. pratiquer votre instrument ou sport habituel à cause de la douleur au bras, à l'épaule ou à la main?	1	2	3	4	5
3. pratiquer votre instrument ou sport habituel aussi bien que vous l'auriez voulu?	1	2	3	4	5
4. passer le même nombre d'heures que d'habitude à pratiquer votre instrument ou sport?	1	2	3	4	5

COTATION DES MODULES OPTIONNELS : Additionnez les valeurs encerclées;
divisez par 4 (nombre d'items); soustraire 1; multipliez par 25.
Un score au module optionnel ne peut pas être calculé si des items ne sont pas répondus.

APPENDIX I: WORC Index (French Canadian)

Western Ontario Rotator Cuff Index

Instructions

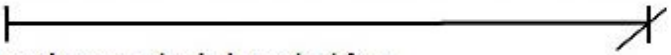
Dans le questionnaire suivant, vous aurez à répondre à des questions dans le format qui suit et vous devrez donner votre réponse en plaçant une barre oblique « / » sur la ligne horizontale.

NOTE :

1. Si vous placez une barre oblique « / » à l'extrême gauche de la ligne, comme dans l'exemple qui suit

vous indiquez alors que vous n'avez aucune douleur.

2. Si vous placez une barre oblique « / » à l'extrême droite de la ligne, comme dans l'exemple qui suit



vous indiquez alors que votre douleur est extrême.

3. Prenez note :
   a) Que plus vous placez votre barre oblique « / » à droite et **plus** vous présentez ce symptôme;
   b) Que plus vous placez votre barre oblique « / » à gauche et **moins** vous présentez ce symptôme;
   c) **Qu'il est important de ne pas placer votre barre oblique « / » en dehors de la ligne horizontale.**

Vous devez indiquer dans ce questionnaire l'intensité des symptômes ressentis dans la dernière semaine en relation avec votre problème d'épaule. Si vous n'êtes pas en mesure de déterminer quelle épaule est concernée ou si vous avez d'autres questions, veuillez demander des précisions avant de compléter ce questionnaire.

Si, pour une raison ou une autre, vous ne comprenez pas une question, s'il vous plaît, référez-vous aux explications qui se trouvent à la fin de ce questionnaire. Vous pourrez par la suite répondre en plaçant une barre oblique « / » sur la ligne horizontale à l'endroit approprié. **Si une question ne s'applique pas à votre situation, ou encore si elle concerne un symptôme qui ne s'est pas présenté au cours de la dernière semaine, veuillez imaginer la réponse qui correspondrait le mieux à votre situation.**

Version originale : The Development and Evaluation of a Disease-Specific Quality of Life Measurement Tool for Rotator Cuff Disease: The Western Ontario Rotator Cuff Index, American Academy of Orthopaedic Surgeon's Annual Meeting Book of Abstracts, 1998.

1

Section A : Symptômes physiques

Instructions

Les questions suivantes concernent les symptômes physiques que vous avez ressentis en relation avec votre problème à l'épaule. Dans tous les cas, veuillez indiquer l'intensité du symptôme ressenti dans la dernière semaine. Veuillez donner votre réponse en plaçant une barre oblique « / » à l'endroit approprié sur la ligne horizontale.

1. Dans quelle mesure éprouvez-vous de la douleur aiguë à votre épaule?

Aucune douleur — Douleur extrême

2. Dans quelle mesure éprouvez-vous de la douleur constante et lancinante à votre épaule?

Aucune douleur — Douleur extrême

3. Dans quelle mesure éprouvez-vous de la faiblesse à votre épaule?

Aucune faiblesse — Faiblesse extrême

4. Dans quelle mesure éprouvez-vous de la raideur ou un manque d'amplitude de mouvement à votre épaule?

Aucune raideur — Raideur extrême

5. Dans quelle mesure êtes-vous dérangé(e) parce que votre épaule claque, grince ou craque?

Aucunement — Extrêmement

6. Dans quelle mesure éprouvez-vous de l'inconfort aux muscles de votre cou en raison de votre épaule

Aucun inconfort — Inconfort extrême

Section B : Sports / Loisirs

Instructions

La section suivante porte sur les conséquences que votre problème d'épaule a eues sur vos activités sportives ou vos loisirs au cours de la dernière semaine. Veuillez donner votre réponse en plaçant une barre oblique « / » à l'endroit approprié sur la ligne horizontale.

7. Dans quelle mesure votre épaule a-t-elle affecté votre condition physique?

8. Dans quelle mesure votre épaule a-t-elle affecté votre capacité à lancer fort ou loin?

9. Dans quelle mesure éprouvez-vous de la difficulté quand quelqu'un ou quelque chose va entrer en contact avec votre épaule atteinte?

10. Dans quelle mesure éprouvez-vous de la difficulté en raison de votre épaule lorsque vous faites des push-ups ou d'autres exercices exigeants pour l'épaule?

Section C : Travail

Instructions

La section suivante porte sur votre problème d'épaule et ses conséquences au cours de la dernière semaine sur vos tâches quotidiennes à l'intérieur et à l'extérieur de la maison. Veuillez donner votre réponse en plaçant une barre oblique « / » à l'endroit approprié sur la ligne horizontale.

11. Dans quelle mesure éprouvez-vous de la difficulté dans vos tâches quotidiennes à la maison ou dans la cour / le jardin?

Aucune difficulté — Difficulté extrême

12. Dans quelle mesure éprouvez-vous de la difficulté à travailler avec le bras au-dessus de l'épaule?

Aucune difficulté — Difficulté extrême

13. Dans quelle mesure utilisez-vous votre autre bras pour compenser pour votre bras atteint?

Pas du tout — Constamment

14. Dans quelle mesure éprouvez-vous de la difficulté quand vous soulevez des objets lourds à hauteur d'épaule ou en-dessous du niveau de l'épaule?

Aucune difficulté — Difficulté extrême

Section D : Style de vie

Instructions

La section suivante porte sur les conséquences que votre problème d'épaule a eues sur votre style de vie au cours de la dernière semaine. Encore une fois, veuillez donner votre réponse en plaçant une barre oblique « / » à l'endroit approprié sur la ligne horizontale.

15. Dans quelle mesure avez-vous de la difficulté à dormir en raison de votre épaule?

Aucune difficulté — Difficulté extrême

16. Dans quelle mesure avez-vous de la difficulté à vous coiffer les cheveux en raison de votre épaule?

Aucune difficulté — Difficulté extrême

17. Dans quelle mesure avez-vous de la difficulté à vous « chamailler », à vous « tirailler » ou à « jouer vivement » avec des membres de votre famille ou des amis?

Aucune difficulté — Difficulté extrême

18. Dans quelle mesure avez-vous de la difficulté à vous habiller ou vous déshabiller?

Aucune difficulté — Difficulté extrême

Section E : Émotions

Instructions

Les questions qui suivent font référence à la façon dont vous vous êtes senti(e) par rapport à votre problème d'épaule au cours de la dernière semaine. Veuillez donner votre réponse en plaçant une barre oblique « / » à l'endroit approprié sur la ligne horizontale.

19. Dans quelle mesure ressentez-vous de la frustration à cause de votre épaule?

20. Dans quelle mesure vous sentez-vous « au fond du baril » ou déprimé en raison de votre épaule?

21. Dans quelles mesures êtes-vous inquiet (inquiète) ou préoccupé(e) par les répercussions de votre problème d'épaule sur votre travail / vos occupations?

MERCI D'AVOIR COMPLÉTÉ LE QUESTIONNAIRE

Explications des questions du WORC

Section A : Symptômes physiques

Question 1.

Fait référence à la douleur à votre épaule qui est brève et soudaine ou que vous pourriez qualifier de momentanée.

Question 2.

Fait référence à une douleur sourde et diffuse qui semble être toujours là comparativement à la douleur aiguë dont il est question à la question 1.

Question 3.

Fait référence à un manque de force pour effectuer un mouvement.

Question 4.

Fait référence à la sensation que l'articulation ne veut pas bouger. Ceci est souvent ressenti le matin au lever, après des exercices ou après une période d'inactivité. Peut aussi faire référence à une diminution de mouvement de votre épaule dans une ou plusieurs directions.

Question 5.

Fait référence à tous ces bruits ou sensations que vous ressentez dans votre épaule peu importe le mouvement que vous exécutez.

Question 6.

Fait référence à l'importance de la tension, de la douleur ou des spasmes que vous ressentez au niveau des muscles de votre cou, qui semblent causés par votre problème d'épaule.

Section B : Sports/Loisirs

Question 7.

Fait référence à la forme physique que vous mainteniez avant le début de votre problème d'épaule (sont incluses une diminution de votre force et de votre tonus musculaire, ou la diminution de votre forme cardiovasculaire).

Question 8.

Fait référence à tout type d'activité avec le bras au-dessus de l'épaule qui demande une certaine force dans son exécution. Si vous ne lancez pas de balle, SVP, considérez toute autre activité comme un smash au volleyball, lancer un bâton à votre chien, nager au crawl, servir au tennis, etc.

Question 9.

Veuillez considérer toute situation où vous étiez sur vos gardes ou avez eu peur que quelqu'un ou quelque chose frappe ou touche votre épaule, comme par exemple, dans un endroit achalandé, dans un ascenseur, pendant la pratique d'un sport ou lorsque quelqu'un vous salue en vous

frappant sur l'épaule.

Question 10.

Fait référence à tout exercice qui vous demande de forcer avec votre épaule comme des « push-ups » ou du « Bench press », etc.

Section C : Travail

Question 11.

Fait référence à des activités comme ratisser les feuilles, pelleter, épousseter, passer l'aspirateur, enlever les mauvaises herbes ou laver le plancher ou des fenêtres, etc.

Question 12.

Fait référence à toute activité demandant que vous leviez vos bras au-dessus de la hauteur des épaules, c'est-à-dire placer des assiettes sur une tablette élevée, essayer d'atteindre un objet, peindre un plafond ou peindre avec le bras au dessus de la hauteur de l'épaule.

Question 13.

Fait référence au fait que vous utilisez votre autre bras pour toute activité ou pour votre travail, alors que normalement, vous auriez accompli cette activité ou ce travail avec votre bras atteint. Si votre autre épaule est aussi symptomatique à cause d'une pathologie de la coiffe des rotateurs ou à cause de toute autre maladie, veuillez, SVP, répondre à la question en faisant comme si votre autre épaule était normale.

Question 14.

Cette question ne fait pas référence au fait de lever des objets lourds au-dessus de la tête, mais bien sous la hauteur des épaules. Par exemple : soulever un sac d'épicerie, une caisse de boissons gazeuses, une valise, du matériel ou des outils au travail, des livres, etc.

Section D : Style de Vie

Question 15.

Fait référence à tout changement dans votre position de sommeil, au fait que vous vous réveillez durant la nuit, que vous avez de la difficulté à vous endormir ou que vous vous réveillez le matin sans vous sentir reposé(e).

Question 16.

Fait référence à tout ce que vous faites à vos cheveux et qui vous demande d'utiliser votre bras problématique. Par exemple : vous peigner, vous brosser ou vous laver les cheveux.

Question 17.

Fait référence à des jeux physiques vigoureux ou exigeants avec votre famille ou vos amis.

Question 18.

Fait référence au fait d'ouvrir ou de fermer une fermeture-éclair située dans votre dos, au fait de boutonner/déboutonner des boutons situés dansvotre dos, d'attacher ou détacher un soutien-

gorge, d'enlever ou de mettre un chandail, ou encore de rentrer une chemise ou un chandail à l'intérieur d'un pantalon.

Section E: Émotions

Question 19.

Fait référence à la frustration que vous ressentez face à votre incapacité, qui vous empêche de faire les choses que vous faites habituellement.

Question 20.

Se sentir au fond du baril : avoir le cafard, être déprimé, triste.

Question 21.

Fait référence à vos inquiétudes face à la condition de votre épaule qui risque de se détériorer plutôt que de s'améliorer, et face aux conséquences que cela pourrait avoir sur vos occupations ou votre travail (considérez aussi les activités quotidiennes à l'intérieur et à l'extérieur de la maison).

Cotation du questionnaire Western Ontario Rotator Cuff Index

1. Mesurez la distance à partir de la gauche de la ligne en millimètres (mm), au 0,5mm près. Inscrire chaque score à l'endroit approprié pour chacune des questions.
2. En additionnant le total des scores obtenus dans chaque domaine, vous obtiendrez un score sur 2100.
3. Pour convertir le score en pourcentage, le score obtenu doit être soustrait à 2100 et divisé par 21. Ex. Pour un score de 1625, le pourcentage sera (2100-1625)/21= 22,6%.

Symptômes physiques

SP1 _____

SP2 _____

SP3 _____

SP4 _____

SP5 _____

SP6 _____

Total : _____

Sports/ Loisirs

S/L 7 _____

S/L 8 _____

S/L 9 _____

S/L 10 _____

Total: _____

Travail

T 11 _____

T 12 _____

T 13 _____

T 14 _____

Total : _____

Style de vie

SV 15 _____

SV 16 _____

SV 17 _____

SV 18 _____

Total : _____

Émotions

E 19 _____

E 20 _____

E 21 _____

Total : _____

Résumé

SP : _____

S/L : _____

T : _____

SV : _____

E : _____

Total : _____

10

APPENDIX J: Edinburg Handedness Inventory (French)

NUMÉRO D'INDENTIFICATION : _____

DATE DE L'ÉVALUATION (JOUR/MOIS/ANNÉE) : ____/____/____.

EDINBURGH HANDEDNESS INVENTORY

ÉTUDE : LES DÉFICITS MOTEURS OBSERVÉS À LA SUITE D'UNE ATTEINTE MUSCULOSQUELETTIQUE PEUVENT-ILS ÊTRE EXPLIQUÉS PAR UNE RÉORGANISATION CENTRALE?

Indiquez votre préférence à utiliser la main gauche ou la main droite pour accomplir les activités suivantes en inscrivant une ou deux croix (+ ou ++) dans la colonne appropriée. Lorsque, pour une activité donnée, vous n'avez pas de préférence et que vous utilisez autant la main gauche que la main droite, placez une croix (+) dans chacune des colonnes. Par contre, si vous avez une préférence marquée pour une main et que vous n'utiliseriez jamais l'autre main à moins d'y être forcé. Inscrivez deux croix (++) dans la colonne appropriée.

Certaines de ces activités requièrent l'usage des deux mains. Dans ces cas, l'identification de la main concernée par la question est écrite entre parenthèses.

Efforcez-vous de répondre à toutes les questions; toutefois, si vous n'avez aucune expérience de l'objet ou de la tâche évoqués dans une question, vous pouvez vous abstenir d'y répondre.

	GAUCHE	DROITE
1. ÉCRIRE	_____	_____
2. DESSINER	_____	_____
3. LANCER	_____	_____
4. CISEAUX (MAIN QUI COUPE)	_____	_____
5. BROSSE À DENT	_____	_____
6. COUTEAU	_____	_____
7. CUILLÈRE	_____	_____
8. BALAI (MAIN SUPÉRIEURE)	_____	_____
9. FROTTER UNE ALLUMETTE	_____	_____
10. OUVRIR UNE BOÎTE (COUVERCLE)	_____	_____
TOTAL	_____	_____

Pour calculer le quotient de latéralité, appliquez la formule suivante :

$$QL = \frac{Md - Mg}{Md + Mg}$$

Md représente le nombre de croix de la colonne main droite

Mg représente le nombre de croix de la colonne main gauche

APPENDIX K: Questionnaire of perception of change and satisfaction (French)

Projet: Efficacité d'un programme de renforcement et de contrôle neuromusculaire des membres supérieurs sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: essai clinique randomisé (Ager et al. 2015) Approbation du CÉR 2015-446

NUMÉRO D'INDENTIFICATION : _____

DATE DE L'ÉVALUATION (JOUR/MOIS/ANNÉE): ____/____/____

Semaine 6 : _____ 3 mois : _____ 6 mois : _____

ÉVALUATION DU CHANGEMENT GLOBAL (GLOBAL RATING OF CHANGE)

Globalement, avez-vous noté un changement dans votre condition à l'épaule depuis l'évaluation initiale? Indiquez s'il y a eu un changement dans votre condition en choisissant parmi les trois options suivantes :

Changement noté	Cochez
1 – Détérioré	
2 – À peu près pareil; ni mieux, ni pire; stable	
3 – Amélioré	

Si votre condition s'est améliorée ou détériorée depuis l'évaluation initiale, évaluez le niveau d'amélioration ou de détérioration en choisissant parmi ces sept options :

Amélioration	Cochez	Détérioration
1 – Un tantinet améliorée		-1 – Un tantinet détériorée
2 – Un petit peu améliorée		-2 – Un petit peu détériorée
3 – Quelque peu améliorée		-3 – Quelque peu détériorée
4 – Modérément améliorée		-4 – Modérément détériorée
5 – Pas mal améliorée		-5 – Pas mal détériorée
6 – Grandement améliorée		-6 – Grandement détériorée
7 – Très grandement améliorée		-7 – Très grandement détériorée

Sur une échelle de 1 à 10 (1 étant aucunement satisfait et 10 étant entièrement satisfait) quel est votre degré de satisfaction global par rapport à vos traitements reçu pour votre problème d'épaule?

0	1	2	3	4	5	6	7	8	9	10
très insatisfait										très satisfait

APPENDIX L: Usual Physiotherapy Care Intervention form (French)

CIRRIS

Projet: Efficacité d'un programme de renforcement et de contrôle neuromusculaire des membres supérieurs sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: essai clinique randomisé (Ager et al. 2015) Approbation du CÉR 2015-446

SOINS HABITUELS - TENDINOPATHIE DE LA COIFFE

No° de participant: _____ No° de traitement: _____ Date: _____

Douleur pré-traitement au repos ____ /10

S.V.P cochez les réponses qui correspondent le mieux aux traitements prodigués **AUJOURD'HUI.**

MODALITÉS: ☐ Glace _____

CONSEILS:
- ☐ PRICES
- ☐ Conseils posturaux
- ☐ Éviter les activités provoquant de la douleur
- ☐ Repos relatif
- ☐ Position de sommeil
- ☐ Conseils sur l'entraînement (Travail physique, PT, travail militaire)

EXERCICES D'AMPLITUDE ARTICULAIRE: (Indiquez direction et paramètres)
- ☐ Actifs _____
- ☐ Actifs-assistés _____
- ☐ Passifs _____
- ☐ Mouvements répétés (précisez si McKenzie, Sahrmann ou autre) _____

_____

ÉTIREMENTS / THÉRAPIE MANUELLE

- ☐ MWMs (Technique Mulligan) _____
- ☐ Thérapie manuelle: mobilisations _____
- ☐ Thérapie manuelle: manipulation _____
- ☐ Exercices de mobilité neurale _____
- ☐ ART (Active Release Therapy) _____
- ☐ Étirements musculaires _____
- ☐ Techniques myofasciales, techniques de tissus mous _____
- ☐ Autre, SVP précisez: _____

EXERCICES DE RENFORCEMENT (ÉLASTIQUE / POULIE / POIDS LIBRES / POIDS DU CORPS)

- ☐ ABDucteurs _____
- ☐ ADDucteurs _____
- ☐ Rotateurs externes _____
- ☐ Rotateurs internes _____
- ☐ Fléchisseurs _____
- ☐ Extenseurs _____
- ☐ Fléchisseurs du coude _____
- ☐ Rétracteurs de l'omoplate _____
- ☐ Protracteurs de l'omoplate _____
- ☐ Musculation cervical _____
- ☐ Musculation dorsale _____
- ☐ Autre: _____

_____ _____

Signature du physiothérapeute **Date**

1

Autre détails: (nombre total de séries et de répétitions, amplitude, résistance):

_____

_____

AUTRES TRAITEMENTS:

☐ Taping : (POSTURAL / NEUROPROPRIOCEPTIF)_____
☐ Rouleau myofascial _____
☐ Traitements de la région cervicale _____
☐ Traitements de la région dorsale _____
☐ Exercices de posture_____
☐ Exercices à chaîne ouverte_____
☐ Exercices à chaîne fermer_____
☐ Exercices de contrôle neuromusculaire_____

_____

EXERCICES À DOMICILE:

☐ _____

☐ _____

☐ _____

☐ _____

☐ _____

AUTRES:

☐ _____

☐ _____

☐ _____

RESTRICTIONS pour _____ jours:

_____

_____

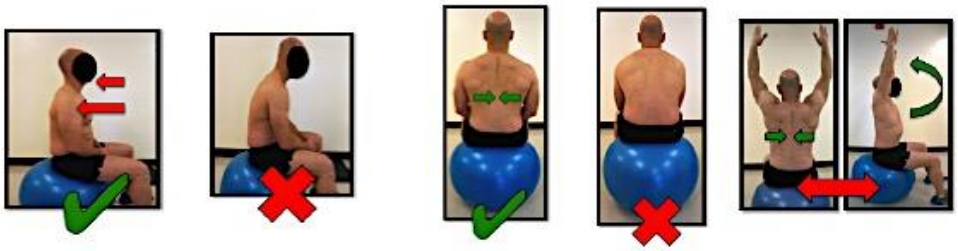
Douleur post-traitement au repos ____ /10

_____ _____
Signature du physiothérapeute **Date**

APPENDIX M: Upper Extremity Neuromuscular Training Program (Visual Guide)

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 1: CONTRÔLE POSTURAL ET SCAPULO-THORACIQUE
Paramètres:1 série de 10 répétitions. 1.1 Maintenir la position pour 10 secondes.



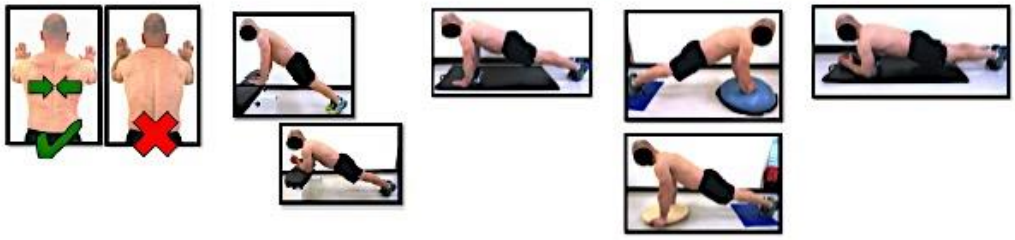
1.1 1.1 1.2

1.3.1 1.3.2 1.4 1.6

(1.5 avec poids libres)

1.2-1.6 Faire 1 série de 15 répétitions.

STATION 2: MISE EN CHARGE Paramètres: Maintenir la position 30 secondes, faire 3 répétitions.



2.1 2.2 2.3 2.4 2.5.1

2.5.2 2.5.3 2.5.4 2.5.5 2.5.6

À partir de 2.5.4 Faire 2 séries de 10 répétitions de chaque côté.

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 3: RÉÉDUCATION NEUROMUSCULAIRE DE LA COIFFE DES ROTATEURS
Paramètres: 3.1: 5 Faire 5 répétitions. Maintenir la position 10 secondes, chaque côté.


3.1


3.2


3.3


3.2.1


3.2.2


3.2.3


3.2.4

Paramètres: 3.2 à 3.4: Faire 2 séries de 15 répétitions.


3.3.1

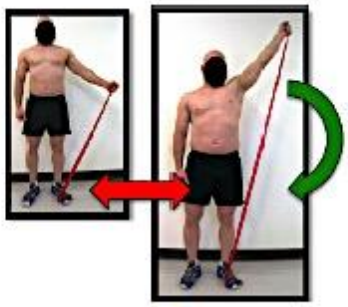

3.3.2


3.3.3


3.3.4

3.4: Pratique des mouvements de rotation externe ou interne (positons variées) avec bande élastique ou poulie en variant les vitesses.

STATION 4: RÉÉDUCATION NEUROMUSCULAIRE DE LA COIFFE DES ROTATEURS (CONTRÔLE MOTEUR EN ÉLÉVATION)


4.1


4.2

4.3 Contrôle scapulo-thoracique en négatif en variant la vitesse des mouvements.

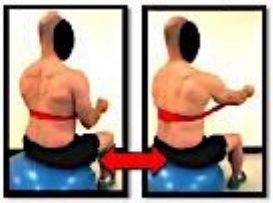
Paramètres: Faire 2 séries de 10 répétitions avec un temps de retour de 10 secondes.

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 5: RÉÉDUCATION NEUROMUSCULAIRE DU DENTELÉ ANTÉRIEUR
Paramètres: Faire 2 séries de 15 répétitions.
5.5 – 5.6: Avec poids libres, élastique, ou poulie.

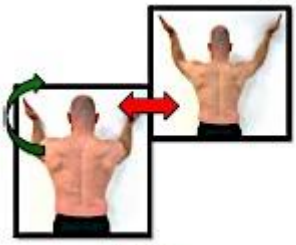
5.1

5.2



5.3

5.4



5.5

5.6

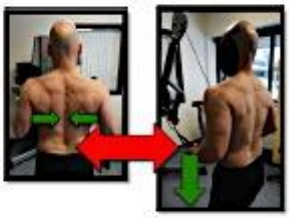
5.7

5.8

5.9

5.10

STATION 6: RÉÉDUCATION NEUROMUSCULAIRE DES TRAPÈZES MOYENS ET INFÉRIEURS Paramètres: Faire 2 séries de 10 répétitions avec un retour de 5 secondes, de chaque côté.



6.1

6.2

6.3

6.4

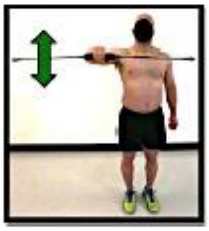
FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 7: STATION BODY BLADE (BB)
Paramètres: Faire 3 répétitions de 15–20 secondes, de chaque côté.

7.1 horizontale

7.2.1 horizontale
7.2.2 verticale

7.3.1 horizontale
7.3.2 verticale



7.4.1 horizontale
7.4.2 verticale

7.5.1
horizontale
7.5.2 verticale

7.6.1 horizontale
7.6.2 verticale

7.7.1a horizontale
7.7.1a verticale

7.7.1b
horizontale
7.7.2b verticale

7.6 – 7.7 : Pertubations avec mouvements.
7.7 Debout sur une surface instable.
a) Sur les deux jambes
b) Sur une jambe

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 8: PROPRIOCEPTION ET CONTRÔLE MOTEUR
Paramètres: Faire3 séries de 20 répétitions.
L'exercice de l'alphabet est à faire jusqu'à ce que vous ressentiez une bonne fatigue musculaire.

8.1.1

8.1.2

8.2

8.3

8.4

Progression:

1. **Petits cercles**
2. **Figure en 8**
3. **Alphabet (A-Z)**

8.3 – 8.4 Progression avec poids libres.

STATION 9: LES LANCERS
Paramètres: Faire 3 séries de 20 répétitions.

9.1
Dribbler un ballon au sol ou au mur avec les 2 bras

9.2
Dribbler un ballon au sol ou au mur avec 1 bras

9.3
Lancer un ballon au mur avec les 2 bras

9.4
Lancer un ballon au mur avec 1 bras

9.5
Pratique des lancers dans plusieurs directions et à différentes vitesses avec bande élastique ou poulie (un bras à la fois).

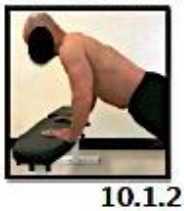
Progression: Au mur, au sol, contre un trampoline, sur des cibles.

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 10: ÉPREUVES FONCTIONNELLES

10.1 PUSH-UPS Paramètres: Faire 3 séries de 20 répétitions.

10.1.1



10.1.2

10.1.3

10.1.4

10.1.5

10.2 PUSH-UPS DYNAMIQUES

Paramètres: Faire 3 séries de 20 répétitions.

10.2.1

Au sol, en appui les coudes, pousser sur les bras (un à la fois) pour monter en appui sur les mains et redescendre au sol

10.2.2

Dans la position push-up, en appui sur les mains, monter sur un obstacle puis redescendre (step / Bosu / disque de stabilité)

10.2.3

10.2.4a

10.2.4b

10.2.4c

Progression:

a) Push-ups avec base de support large (les coudes vers l'extérieur)
b) Push-ups de triceps (les bras près du corps)
c) Push-ups du diamant (avec les pouces et l'index qui se touchent)

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

10.3 STATION DE 'BENCH PRESS'
Paramètres: Faire 2 séries de 15 répétitions.

10.3.1

10.3.2

10.3.3 Pratique du mouvement de 'bench press' à différentes vitesses

PROGRESSION: Sans charge, avec poids libres, avec barre de bench press, avec barre de bench press et poids.

10.4 STATION DES MOUVEMENTS FONCTIONNELS COMBINÉS
Paramètres: 2 séries de 15 répétitions. 10.4.1-2: bilatéralement.

10.4.1

10.4.2

10.4.3

10.4.4

10.5 STATION DE MANIPULATION DE SACS DE SABLE (STANDARD DU TEST FORCE) 10.5.1 – 4

10.5

Paramètres:

- **Débutant**: 3 séries de 10 répétitions.
- **Intermédiaire**: 3 séries de 15 répétitions.
- **Avancé:** 30 soulèvements en 4 minutes.

Progression:

1. **Sans charge**
2. **Poids libre**
3. **Kettle bell**
4. **Sac de sable**

FEUILLE DE ROUTE DU PROGRAMME DE RENFORCEMENT ET CONTRÔLE NEUROMUSCULAIRE DU MEMBRE SUPÉRIEUR

STATION 11: MOUVEMENT Y EN MISE EN CHARGE (SFMA Y BALANCE TEST)
Paramètres: Faire 5 répétitions du mouvement dans chaque direction avec chaque bras.

Position de départ

Direction médiale

Direction inféro-latérale

Direction supéro-latérale

DIRECTIVES:

1. Enlever les chaussures avant d'entamer le test.
2. Se placer en position *push up* avec une main (droite ou gauche) sur le centre de la plaque d'appui. La main doit être derrière la ligne rouge et parallèle au bord de la plaque.
3. Placer le bout de l'autre main sur la boîte mobile du côté opposé à votre bras fixe.
4. Tout en maintenant la main fixée sur la plaque d'appui, avec l'autre main, pousser sur la zone rouge. Il faut pousser la boîte aussi loin que possible tout en gardant un bon contrôle du mouvement. La main doit maintenir un contact régulier avec la portion rouge de la boîte (ne pas lancer ou utiliser le momentum pour effectuer le mouvement). Il ne faut pas utiliser la boîte mobile comme appui.
5. Ramener la main à la position de départ avec un bon contrôle du mouvement, en gardant la position push up et sans toucher le sol avec la main en action.
6. Refaire les mêmes étapes mais, cette fois, pour la boîte du même côté que le bras en appui et, ensuite, pour la boîte devant vous.
7. Répéter deux autres fois.
8. Faire trois essais par mouvement, et ce, pour chaque bras.

N.B Vous devez effectuer chaque mouvement trois fois avant d'alterner le bras de support dans le même direction. Ceci est considéré une répétition.

APPENDIX N: Upper Extremity Neuromuscular Training Program (Patient Tracking Sheet)

Feuille de route du programme de renforcement et contrôle neuromusculaire du membre supérieur

Nom du participant: _____ Date: _____

Matricule : _____ Unité : _____

STATION 1: CONTRÔLE POSTURAL ET SCAPULO-THORACIQUE Paramètres:1 série de 10 répétitions. 1.1 Maintenir la position pour 10 secondes.														
	Semaine 1		Semaine 2		Semaine 3		Semaine 4		Semaine 5		Semaine 6		Semaine 7	
1.1 Posture et contrôle scapulo-thoracique sur ballon d'exercice														
1.2 Contrôle scapulo-thoracique en flexion (élévation) assis sur ballon d'exercice														
1.3 Couché sur le ventre sur un ballon, pratique des mvts de <Y>														
1.3.1 Mvts avec les paumes des mains vers le haut														
1.3.2 Mvts avec les paumes des mains vers le bas														
1.4 Couché sur le ventre sur un ballon, pratique des mvts de <W>														
1.5 Couché sur un ballon, pratique des mvts de <Y> et <W> avec poids libres														
1.6 Couché sur un ballon, incliné, passer un ballon entre les mains														
STATION 2: MISE EN CHARGE Paramètres: 3 répétitions, maintenir la position 30 secondes. A partir de 2.5.4, 2 séries de 10 répétitions de chaque côté.														
2.1 Mise en charge au mur														
2.2 Mise en charge à 45° (sur plan incliné)														
2.3 Mise en charge au sol (en appui sur les mains)														
2.4 Mise en charge sur surfaces instables (Bosu, planche d'équilibre, disque)														
2.5 Position de planche														
2.5.1 Planche ventrale (sur les coudes ou les mains)														
2.5.2 Planche latérale (sur les coudes ou les mains, des deux côtés)														
2.5.3 Au sol, en position avec bras pointés d'appui														
2.5.4 Planche dynamique sur les coudes														
2.5.5 Planche dynamique sur les mains														
2.5.6 Planche dynamique avec poids libres														

STATION 1: RÉÉDUCATION NEUROMUSCULAIRE DE LA COIFFE DES ROTATEURS (ROTATION INTERNE (RI) ET EXTERNE (RE)) Paramètres: 3.1: 6 répétitions de 10 secondes (chaque côté). 3.2 à 3.5: 2 séries de 15 répétitions.																		
3.1 Déplacement latéral du corps avec résistance d'un élastique (les coudes pliés)	Semaine 1			Semaine 2			Semaine 3			Semaine 4			Semaine 5			Semaine 6		
3.1.1 Prise de la bande élastique avec les deux mains																		
3.1.2 Prise de la bande élastique avec une main (bande vers l'extérieur, déplacement vers l'intérieur)																		
3.1.3 Prise de la bande élastique avec une main (bande vers l'intérieur, déplacement vers l'extérieur)																		
3.2 Mouvement de rotation externe (RE)																		
3.2.1 Pratique des mvts de RE (coude plié et collé contre le corps) avec bande élastique ou poulie, en position debout ou sur ballon																		
3.2.2 Pratique des mvts de RE (bras décollé du corps à 45°) avec bande élastique ou poulie, en position debout ou sur ballon																		
3.2.3 Pratique des mvts de RE (bras décollé du corps à 90°) avec bande élastique ou poulie, en position debout ou sur ballon																		
3.2.4 Pratique des mvts résistés en RE couché sur le côté, avec poids libre																		
3.3 Mouvement de rotation interne (RI)																		
3.3.1 Pratique des mvts de RI (coude plié et collé contre le corps) avec bande élastique ou poulie en position debout ou sur ballon																		
3.3.2 Pratique des mvts de RI (bras décollé du corps à 45°) avec bande élastique ou poulie en position debout ou sur ballon																		
3.3.3 Pratique des mvts de RI (bras décollé du corps à 90°) avec bande élastique ou poulie en position debout ou sur ballon																		
3.3.4 Pratique des mvts résistés en RI couché sur le dos, (bras décollé du corps à 90°) avec poids libre																		
3.4 Pratique des mvts de RE ou RI (positons variées) avec bande élastique ou poulie en variant les vitesses																		
STATION 4: RÉÉDUCATION NEUROMUSCULAIRE (CONTRÔLE MOTEUR EN ÉLÉVATION) Paramètres: 2 séries de 10 répétitions avec retour sur 10 secondes.																		
4.1 Contrôle scapulo-thoracique en négatif avec bande élastique (debout sur l'élastique)																		
4.2 Contrôle scapulo-thoracique en négatif avec poids libres																		
4.3 Contrôle scapulo-thoracique en négatif en variant la vitesse des mouvements																		
STATION 5: RÉÉDUCATION NEUROMUSCULAIRE DU DENTELÉ ANTÉRIEUR Paramètres: 2 séries de 15 répétitions.																		
5.1 Pratique des mvts de protraction et rétracton en mise en charge contre le mur																		
5.2 Pratique des mvts de protraction et rétracton en mise en charge au sol																		
5.3 Pratique des mvts de protraction résistée avec bande élastique (assis sur ballon ou debout, unilatéral ou bilatéral)																		
5.4 Pratique des mvts résistés de <W> contre le mur en flexion (élévation)																		
5.5 Pratique des mvts résistés de <W> contre le mur en diagonal																		

STATION 5: RÉÉDUCATION NEUROMUSCULAIRE DU DENTELÉ ANTÉRIEUR Paramètres: 2 series de 15 repetitions.																		
	Semaine 1			Semaine 2			Semaine 3			Semaine 4			Semaine 6			Semaine 8		
5.6 Pratique des mvts résistés de <W> contre le mur, en flexion, avec poids libres, bande élastique ou poulie																		
5.7 Pratique des mvts résistés de <W> contre le mur, en diagonal, avec poids libres, bande élastique ou poulie																		
5.8 Pratique de la flexion (élévation) résistée coudes pliés, avant-bras et paumes des mains vers soi																		
5.9 Pratique de la flexion résistée coudes pliés les avant-bras et paumes des mains vers soi, avec poids libres ou bande élastique																		
5.10 Pratique des mvts du développé militaire avec poids libres																		
STATION 6: RÉÉDUCATION NEUROMUSCULAIRE DES TRAPÈZES MOYENS ET INFÉRIEURS Paramètres: 2 séries de 10 répétitions (retour sur 5 secondes), bilatéralement.																		
6.1 Pratique des mvts de "pull downs"																		
6.2 Pratique des mvts de "pull ups"																		
6.3 Pratique des mvts de rameur (pull back rows) bras près du corps																		
6.4 Pratique des mvts de rameur (pull back rows) les bras à 90°																		
STATION 7: STATION BODY BLADE (BB) Paramètres: 3 répétitions de 15-30 secondes, chaque bras.																		
7.1 Pratique du contrôle du BB en position debout (coude droit, bras collé au corps)																		
7.1.1 Perturbations horizontales																		
7.1.2 Perturbations verticales																		
7.2 Pratique du contrôle horizontal du BB en position debout (bras à 90° de côté)																		
7.2.1 Perturbations horizontales																		
7.2.2 Perturbations verticales																		

STATION 3: RÉÉDUCATION NEUROMUSCULAIRE DE LA COIFFE DES ROTATEURS (ROTATION INTERNE (RI) ET EXTERNE (RE)) Paramètres: 3.1: 6 répétitions de 10 secondes (chaque côté). 3.2 à 3.5: 2 séries de 15 répétitions.																			
3.1 Déplacement latéral du corps avec résistance d'un élastique (les coudes pliés)	**Semaine 1**			**Semaine 2**			**Semaine 3**			**Semaine 4**			**Semaine 5**			**Semaine 6**		
3.1.1 Prise de la bande élastique avec les deux mains																			
3.1.2 Prise de la bande élastique avec une main (bande vers l'extérieur, déplacement vers l'intérieur)																			
3.1.3 Prise de la bande élastique avec une main (bande vers l'intérieur, déplacement vers l'extérieur)																			
3.2 Mouvement de rotation externe (RE)																			
3.2.1 Pratique des mvts de RE (coude plié et collé contre le corps) avec bande élastique ou poulie, en position debout ou sur ballon																			
3.2.2 Pratique des mvts de RE (bras décollé du corps à 45°) avec bande élastique ou poulie, en position debout ou sur ballon																			
3.2.3 Pratique des mvts de RE (bras décollé du corps à 90°) avec bande élastique ou poulie, en position debout ou sur ballon																			
3.2.4 Pratique des mvts résistés en RE couché sur le côté, avec poids libre																			
3.3 Mouvement de rotation interne (RI)																			
3.3.1 Pratique des mvts de RI (coude plié et collé contre le corps) avec bande élastique ou poulie en position debout ou sur ballon																			
3.3.2 Pratique des mvts de RI (bras décollé du corps à 45°) avec bande élastique ou poulie en position debout ou sur ballon																			
3.3.3 Pratique des mvts de RI (bras décollé du corps à 90°) avec bande élastique ou poulie en position debout ou sur ballon																			
3.3.4 Pratique des mvts résistés en RI couché sur le dos, (bras décollé du corps à 90°) avec poids libre																			
3.4 Pratique des mvts de RE ou RI (positons variées) avec bande élastique ou poulie en variant les vitesses																			
STATION 4: RÉÉDUCATION NEUROMUSCULAIRE (CONTRÔLE MOTEUR EN ÉLÉVATION) Paramètres: 2 séries de 10 répétitions avec retour sur 10 secondes.																			
4.1 Contrôle scapulo-thoracique en négatif avec bande élastique (debout sur l'élastique)																			
4.2 Contrôle scapulo-thoracique en négatif avec poids libres																			
4.3 Contrôle scapulo-thoracique en négatif en variant la vitesse des mouvements																			
STATION 5: RÉÉDUCATION NEUROMUSCULAIRE DU DENTELÉ ANTÉRIEUR Paramètres: 2 séries de 15 répétitions.																			
5.1 Pratique des mvts de protraction et rétraction en mise en charge contre le mur																			
5.2 Pratique des mvts de protraction et rétraction en mise en charge au sol																			
5.3 Pratique des mvts de protraction résistée avec bande élastique (assis sur ballon ou debout, unilatéral ou bilatéral)																			
5.4 Pratique des mvts résistés de <W> contre le mur en flexion (élévation)																			
5.5 Pratique des mvts résistés de <W> contre le mur en diagonal																			

STATION 8: PROPRIOCEPTION ET CONTRÔLE MOTEUR **Paramètres: 3 séries de 20 répétitions. L'exercice de l'alphabet est à faire jusqu'à ce que vous ressentiez une bonne fatigue musculaire.**																	
Progression: 8.1.1 - 8.1.2 Petits cercles, figure en 8, alphabet (A-Z). 8.2 - 8.4 avec poids libre.	**Semaine 1**			**Semaine 2**			**Semaine 3**			**Semaine 4**			**Semaine 5**			**Semaine 6**	
8.1.1 Dessiner des cercles au mur, bras près du corps (grands vers petits / lents vers rapides)																	
8.1.2 Dessiner des cercles au mur, bras à l'horizontal (grands vers petits / lents vers rapides)																	
8.2 Couché sur le dos sur le ballon d'exercice, dessiner des cercles, le bras en élévation																	
8.3 Couché sur le dos sur le ballon d'exercice, dessiner des cercles, le bras de côté à 90°																	
8.4 Couché sur le ventre sur le ballon d'exercice, dessiner des cercles, le bras de côté à 90°																	
STATION 9: LES LANCERS Paramètres: 3 séries de 20 répétitions. N.B. Tous les mvts sont à faire en gardant un bon contrôle scapulo-thoracique.																	
Progression: Au mur, au sol, contre un trampoline, contre des cibles																	
9.1 Dribbler un ballon au sol ou au mur avec les 2 bras																	
9.2 Dribbler un ballon au sol ou au mur avec 1 bras																	
9.3 Lancer un ballon au mur avec les 2 bras																	
9.4 Lancer un ballon au mur avec 1 bras																	
9.5 Pratique des lancers dans plusieurs directions et à différentes vitesses avec bande élastique ou poulie (un bras à la fois)																	
STATION 10: STATION ÉPREUVES FONCTIONNELLES																	
10.1 PUSH-UPS Paramètres: 3 séries de 20 répétitions.																	
10.1.1 Au mur																	
10.1.2 Sur plan incliné																	
10.1.3 Au sol																	

STATION 10: STATION ÉPREUVES FONCTIONNELLES																		
10.1 PUSH-UPS Paramètres: 3 séries de 20 répétitions.	Semaine 1			Semaine 2			Semaine 3			Semaine 4			Semaine 5			Semaine 6		
10.1.4 Au sol, sur surface instable (Bosu, planche d'équilibre ou disque de stabilité)																		
10.1.5 Push-ups tombants à partir de la position à genoux, les pieds sécurisés																		
10.2 PUSH-UPS DYNAMIQUES Paramètres: 3 séries de 20 répétitions.																		
10.2.1 Au sol, en appui les coudes, pousser sur les bras (un à la fois) pour monter en appui sur les mains et redescendre au sol																		
10.2.2 Dans la position push-up, en appui sur les mains, monter sur un obstacle puis redescendre (step / Bosu / disque de stabilité)																		
10.2.3 Push-ups sur surface instable (Bosu / planche d'équilibre / disque de stabilité)																		
10.2.4 Push-ups avec frappe des mains																		
PROGRESSION: A) PUSH-UPS AVEC BASE DE SUPPORT LARGE (les coudes vers l'extérieur) B) PUSH-UPS DE TRICEPS (les bras près du corps) C) PUSH-UPS DU DIAMANT (avec les pouces et l'index qui se touchent)																		
STATION 10.3 STATION DE "BENCH PRESS" Paramètres: 2 séries de 15 répétitions. PROGRESSION: Sans charge, avec poids libres, avec barre de bench press, avec barre de bench press et poids.																		
10.3.1 Pratique du mvt de bench press sur banc d'exercice																		
10.3.2 Pratique du mvt de bench press couché sur ballon d'exercice																		
10.3.3 Pratique du mvt de bench press à différentes vitesses																		
10.4 STATION DES MVTS FONCTIONNELS COMBINÉS Paramètres:2 séries de 15 répétitions.10.4.1-2: de chaque côté																		
10.4.1 Mvt de tir à l'arc avec bande élastique																		
10.4.2 En position quatre pattes, élastique sous le genou, lever le bras à l'horizontal contre la résistance de l'élastique ainsi que la jambe opposée																		
10.4.3 Pratique du mvt de squat avec bande élastique sous tension entre les deux mains au-dessus de la tête																		
10.4.4 En position à genoux, les avants-bras sur un ballon d'exercice, faire rouler le ballon vers l'avant																		

STATION 10: STATION ÉPREUVES FONCTIONNELLES																		
10.5 STATION DE MANIPULATION DE SACS DE SABLE (STANDARD DU TEST FORCE)	Semaine 1			Semaine 2			Semaine 3			Semaine 4			Semaine 5			Semaine 6		
10.5.1 Ramasser une charge au sol avec un poids libre ou kettle bell																		
10.5.2 Niveau débutant: Sac de sable: 3 séries de 10 répétitions																		
10.5.3 Niveau intermédiaire: Sac de sable: 3 séries de 15 répétitions																		
10.5.4 Niveau avancé: Sac de sable: 30 soulèvements en 4 minutes																		
STATION 11: MOUVEMENT Y EN MISE EN CHARGE (SFMAY BALANCE TEST) Paramètres: 1 rnvt dans chaque direction, 3 fois.																		
DIRECTIVE: Pointer avec la main libre aussi loin que possible dans 3 directions sans compensation du tronc																		

APPENDIX O: Scientific approval from the Scientific Committee of the CIRRIS / IRDPQ

CRIR
Centre de recherche interdisciplinaire en réadaptation du Montréal Métropolitain
Comité scientifique

CIRRIS
Centre interdisciplinaire de recherche en réadaptation et intégration sociale

4 Septembre, 2015

Dr. Luc J Hébert, PhD
Département de Réadaptation
Université Laval

Cher Dr. Hébert,

La présente lettre vous confirme que le comité d'évaluation scientifique a jugé votre projet (CIRRIS-15-0715 **Effectiveness of the Upper Extremity Neuromuscular training Program (UpEx-NTP) on shoulder function of people with rotator cuff tendinopathies : A Randomized Control Trial**) conforme aux standards scientifiques en vigueur. Cette lettre, les grilles d'évaluation, ainsi que votre protocole de recherche seront inclus dans votre dossier soumis au Comité d'éthique. Les responsables du comité d'éthique feront le suivi avec vous quant au progrès de votre projet.

Veuillez agréer, l'expression de mes sentiments les meilleurs,

Julio Côté, Ph.D.
Présidente
Comité d'évaluation scientifique CRIR/CIRRIS
Téléphone : (514) 398-4184 poste 0539
Courriel : julio.cote2@mcgill.ca

APPENDIX P: Ethical Approval (CIRRIS - IRDPQ)

Québec

Certificat d'éthique

Projet de recherche

Québec, le 4 novembre 2015

Nous attestons que les membres du comité d'éthique de la recherche de l'Institut de réadaptation en déficience physique de Québec ont évalué le projet de recherche # 2015-446 «Efficacité d'un programme de renforcement et de contrôle neuromusculaire du membre supérieur sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: un essai clinique randomisé. », lors de la séance du 22 octobre 2015.

Soumis par : **Luc J. Hébert, Ph.D.**
Collaboration en affiliation avec le CIRRIS ou l'Université Laval :
Jean-Sébastien Roy, Ph.D.

Les membres du comité sont :

- Sylvain Auclair (spécialiste en éthique)
- Lucie D'Anjou (représentante clinique)
- Jean J Frenette (représentant des utilisateurs de services)
- Ariane Imreh (spécialiste en droit)
- Johanne Lambert (représentante des gestionnaires cliniques)
- Désirée Maltais (personne ayant une vaste connaissance de la recherche)
- Pascal Minville (représentant des utilisateurs de services)
- Jacques Vachon (personne ayant une vaste connaissance de la recherche)
- Julien Voisin (personne ayant une vaste connaissance de la recherche)

Nous certifions que ce projet de recherche est conforme au point de vue de l'éthique et qu'il est approuvé **jusqu'au 30 janvier 2016.**

Sylvain Auclair, président du comité d'éthique de la recherche de l'IRDPQ

☐ c.c. : CÉR des établissements du CRIR
☒ c.c. : Mme Line Bazuregard, coordonnatrice du CÉR
☒ c.c. : Mme Linda Girard, CIRRIS

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Québec

Institut de réadaptation en déficience physique de Québec

Certificat d'éthique

Projet de recherche

Québec, le 30 janvier 2017

À la lumière des informations qui nous ont été transmises, les membres du comité d'éthique de la recherche de l'Institut de réadaptation en déficience physique de Québec autorisent le renouvellement du certificat d'éthique pour le projet de recherche # **2015-446** « **Efficacité d'un programme de renforcement et de contrôle neuromusculaire du membre supérieur sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs: un essai clinique randomisé**».

Soumis par : **Luc J. Hébert, Ph.D.**
Collaboration en affiliation avec le CIRRIS ou l'Université Laval :
Jean-Sébastien Roy, Ph.D.

Les membres du comité sont :

- Sylvain Auclair (spécialiste en éthique)
- Lucie D'Anjou (représentante clinique)
- (vacant) (représentant des utilisateurs de services)
- Ariane Imreh (spécialiste en droit)
- Johanne Lambert (représentante des gestionnaires cliniques)
- Désirée Maltais (personne ayant une vaste connaissance de la recherche)
- Pascal Minville (représentant des utilisateurs de services)
- Jacques Vachon (personne ayant une vaste connaissance de la recherche)
- Julien Voisin (personne ayant une vaste connaissance de la recherche)

Nous certifions que ce projet de recherche est conforme aux exigences du comité d'éthique de la recherche et que le certificat d'éthique est renouvelé **jusqu'au 30 janvier 2018.**

Sylvain Auclair, président du comité d'éthique de la recherche de l'IRDPQ

☒ c. c. : Linda Girard, Sylvie Racine (CIRRIS)

APPENDIX Q: Letter from Surgeon General of the Canadian Armed Forces

Canadian Forces Health Services Group Headquarters
1745 Alta Vista Drive
Ottawa, ON
K1A 0K6

1000-1 (S&T Mgr)

15 Dec 15

Amanda Ager
Centre interdisciplinaire de recherche en réadaptation et en intégration sociale (CIRRIS)
Institut de réadaptation en déficiences physique de Québec (IRDPQ)
525, boulevard Wilfrid-Hamel, local H-0612
Québec, QC
G1M 2S8

RESEARCH APPROVAL

1. On behalf of the Surgeon General's Health Research Board, I am pleased to support your study on "*Effectiveness of the Upper Extremity Neuromuscular training Program (UpEx-NTP) on shoulder function of military members affected by rotator cuff tendinopathies: A Randomized Control Trial*". Your research will help to support the Surgeon General's clinic practice guidelines for Primary Care.

2. This is an interesting topic, and the information gleaned from your study could usefully inform new guidelines for the management of rotator cuff tendinopathies. We look forward to seeing the results from your work.

R.M. Poisson
Lieutenant Colonel
Science & Technology Manager
(613) 945-6665

APPENDIX R: Awarded Grant: REPAR-OPPQ Program 4.2 for a clinical study

REPAR FRQS

Réseau provincial en adaptation-réadaptation

Ordre professionnel de la physiothérapie du Québec

Montréal, le 2 juin 2016

Objet : *Programme OPPQ/REPAR*

Titre : *« Efficacité d'un programme de renforcement et de contrôle neuromusculaire du membre supérieur sur la fonction de l'épaule de personnes ayant une tendinopathie de la coiffe des rotateurs : Un essai clinique randomisé »*

Co-chercheurs : Luc J. Hébert, Jean-Sébastien Roy, France Gamache, Myriam Cyr, Sophie Bernard, Pierre-Marc Vézina, Anny Fredette

Programme : 4.2.1 **Demande de support : 2016-17-#2**

Madame,

Nous avons le plaisir de vous informer que votre candidature a été retenue dans le cadre du partenariat OPPQ-REPAR et que celui-ci accepte de supporter votre demande dont le titre apparaît en rubrique.

Un budget de 15,000 $ a été approuvé

Le montant de la subvention vous sera versé sur réception d'une attestation de conformité en éthique émise par un comité d'éthique de la recherche. De plus, le REPAR vous incite à consulter la section « Engagement du récipiendaire » sur le site Web du REPAR (Programme de recherche clinique en physiothérapie) afin de respecter les conditions associées à l'acceptation de cette subvention. Les évaluations de votre demande sont jointes à cette lettre.

1/2

Par la présente, nous vous prions de faire parvenir une copie de cet avis d'octroi à chacun de vos collègues, co-chercheurs. En recevant ce support, vous acceptez la responsabilité de soumettre un rapport d'étape scientifique et financier 12 mois après le début du projet de recherche et un rapport final 3 mois après la fin du projet de recherche. De plus, vous êtes tenu de produire un article pour la chronique des récipiendaires de la revue Physio-Québec de l'OPPQ. Tout membre d'une équipe qui n'aura pas répondu à ces exigences, se verra dans l'impossibilité d'obtenir une autre subvention des deux organismes.

Nous vous souhaitons la meilleure des chances dans la réalisation de votre projet de recherche.

Veuillez agréer, monsieur, l'expression de nos salutations distinguées.

Le Directeur scientifique,

Le président de l'OPPQ.

Daniel Bourbonnais, erg., Ph.D.

Denis Pelletier, pht, M. Sc.

DB/lb

p.j.: Évaluations

c.c.: Mme Marjolaine Lajoie, mlajoie@oppq.qc.ca

APPENDIX S: Awarded Student Bursary from CIRRIS and Laval University

CIRRIS
Centre interdisciplinaire de recherche en réadaptation et intégration sociale

Québec, le 5 juillet 2016

Madame Amanda Ager
518, Avenue des Oblats, app.1
Québec (Qc) G1N 1V6

Objet : Votre demande au Programme de bourses du CIRRIS 2016-2017

Le Conseil de recherche s'est réuni le 21 juin dernier pour examiner et évaluer les demandes de bourses qui ont été soumises au Programme de bourses de 2e et de 3e cycles 2016-2017.

Il me fait plaisir de vous annoncer que votre demande a été retenue et que le Programme de bourse du CIRRIS vous octroie une bourse de 2e cycle. Cette bourse est de 12 000 $ pour la période s'échelonnant du 1er septembre 2016 au 30 août 2017 (1an). Selon les règles du programme, le CIRRIS et votre directeur contribueront à parts égales à cette bourse. Je vous demande de contacter Mme Linda Girard vers le début du mois d'août 2016 pour qu'elle prenne les dispositions nécessaires au paiement de votre bourse. Cette bourse est conditionnelle à ce que vous soyez inscrit(e) au registre du CIRRIS et que cette inscription soit comptabilisable au niveau performance du Centre pour toute la durée de cette bourse.

Tel que stipulé dans les règles du Programme, vous devez présenter des demandes de bourses à des organismes externes et si une offre de bourse vous est faite par un de ces organismes pour la même période en totalité ou en partie, vous êtes tenu de l'accepter et d'en aviser la direction du CIRRIS aussitôt et de la faire démarrer le plus tôt possible. Si la bourse externe est inférieure à celle du Programme de bourse du CIRRIS, le Programme comblera la différence si le cumul de bourses est permis par l'organisme externe. Si la bourse externe est supérieure à celle du Programme, cette dernière cessera dès l'entrée en vigueur de la bourse externe. Vous devez demander que votre bourse externe débute le plus

UNIVERSITÉ LAVAL

Centre intégré universitaire de santé et de services sociaux de la Capitale-Nationale
Québec

525 Boul. Hamel, Québec. Qc. G1M 2S8 Tél : (418) 649-3735 www.cirris.ulaval.ca

tôt possible. De plus, vous vous engagez à consacrer un minimum de 30 heures par semaine (en moyenne) à ses activités de formation en recherche au cours de la période de la bourse.

Je vous offre, au nom du Conseil de recherche et en mon nom personnel, toutes mes félicitations.

Lyne Kelly
Adjointe au directeur

c.c. : Luc J. Hébert, Directeur des études