

COVER PAGE OF THE STUDY PROTOCOL

Title of the Study:

Effect of Joint Mobilization and Movement Control Exercises on Shoulder Pain and Function in Fast Bowlers (RCT)

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1. Background & Literature Review

Overhead athletes frequently develop biomechanical adaptations in the glenohumeral joint due to repetitive throwing or bowling activities. One of the most common adaptations is Glenohumeral Internal Rotation Deficit (GIRD), which is characterized by reduced shoulder internal rotation along with compensatory increases in external rotation. GIRD is considered pathological when the loss of internal rotation exceeds 18–20° and total rotational motion decreases compared to the non-dominant shoulder. These alterations are associated with posterior capsule tightness, muscular imbalance, altered joint mechanics, and increased risk of shoulder injuries.(1,2)

Repetitive overhead activities in sports such as baseball, volleyball, handball, water polo, and cricket expose the shoulder complex to excessive stress. Studies have demonstrated a high prevalence of GIRD among overhead athletes, with evidence showing that athletes with GIRD are at greater risk of shoulder dysfunction and injury.(3–5) Repeated tensile stress during the follow-through phase may lead to inflammation, scar formation, and tightening of posterior shoulder structures, including the posterior capsule and muscles such as the infraspinatus and teres minor.(6,7) In fast bowlers, repetitive bowling actions can produce microtrauma to capsuloligamentous and muscular tissues, contributing to restricted internal rotation and impaired shoulder function.(8)

Previous studies investigating interventions for GIRD have shown several limitations, including heterogeneous athletic populations, lack of appropriate control groups, and emphasis on short-term outcomes.(9) Many studies focused mainly on asymptomatic athletes, limiting the generalizability of findings to symptomatic sports populations. Traditional stretching techniques such as sleeper stretches and cross-body stretches have demonstrated improvements in shoulder range of motion; however, concerns remain regarding improper scapular stabilization, symptom aggravation, and increased risk of subacromial impingement. (15-18)

Mulligan Mobilization with Movement (MWM) is a widely used manual therapy technique in musculoskeletal rehabilitation. It involves the application of a sustained accessory glide while the patient actively performs movement, aiming to correct positional faults, reduce pain, and restore normal movement patterns.(10) Research supports the effectiveness of MWM in improving joint mobility and reducing discomfort in individuals with shoulder dysfunction.

Kinetic control training is another rehabilitation strategy focusing on movement coordination, scapular stability, and neuromuscular control. This approach emphasizes identifying and correcting uncontrolled movement patterns through targeted exercises based on biomechanical assessment and

muscle activation patterns.(11,12) Improving motor control of muscles such as the subscapularis, infraspinatus, teres major, and teres minor may enhance shoulder stability and optimize functional movement in overhead athletes.

Recent evidence suggests that combining manual therapy with movement control exercises may produce better outcomes than stretching alone. Studies have reported improvements in shoulder internal rotation, pain reduction, and upper limb function following mobilization and exercise-based interventions.(9,13–17) However, limited evidence exists regarding the combined effects of Mulligan Mobilization with Movement and kinetic medial rotation control specifically in fast bowlers with symptomatic GIRD.

Therefore, this study aims to evaluate the effects of Mulligan Mobilization with Movement combined with kinetic medial rotation control exercises on pain, range of motion, and shoulder function among fast bowlers with internal rotation deficit. The findings may contribute to safer and more effective rehabilitation strategies for overhead athletes with shoulder dysfunction.

2. Research Objectives

- To determine the effects of Mulligan mobilization with movement in addition to kinetic control for medial rotation for the glenohumeral joint on pain, range of motion (ROM), and shoulder function in fast bowlers with internal rotation deficit.

3. Research Questions / Hypotheses

Null Hypothesis: There is no significant difference in the effects of Mulligan mobilization with movement along with kinetic medial rotation control on pain, range of motion, and shoulder function among fast bowlers with internal rotation deficit.

$$H_0: \mu_1 = \mu_2$$

Alternative Hypothesis: There is a significant difference in the effects of Mulligan mobilization with movement along with kinetic medial rotation control on pain, range of motion, and shoulder function among fast bowlers with internal rotation deficit.

$$H_1: \mu_1 \neq \mu_2$$

4. Methodology

a. Research Design

Randomized Controlled Trial

b. Study Population and Setting

Fast Bowlers with glenohumeral internal rotation deficit from Paragon Cricket Club, Lahore and Demon Warriors Cricket Club, Lahore

c. Sampling Strategy And Size

Non-probability (Convenience Sampling) will be used while selecting a sample of athletes from cricket clubs. Sample size was calculated by G* Power 3.1.9.4 with level of significance ($\alpha=0.05$), power 80%, and effect size of 0.19 for glenohumeral internal rotation ROM.(9) The required sample size is 50 (42+8) with a 20% dropout rate.

Figure 1: Sample Size Calculation by G Power 3.1.9.4*

d. Inclusion/Exclusion Criteria

Inclusion Criteria

Male cricketers aged between 18 and 45 years will be recruited for this study.(9) Participants must be actively involved in regular cricket training and specifically participate as fast bowlers.(19) Eligible participants should report persistent mild to moderate shoulder pain during overhead activities lasting for more than three months. In addition, participants must demonstrate Glenohumeral Internal Rotation Deficit (GIRD) greater than 10°, assessed using a goniometer by comparing internal rotation range between the dominant and non-dominant shoulders.(20)

Exclusion Criteria

Participants with a recent history of shoulder or elbow surgery, including rotator cuff repair or arthroscopic labral repair within the previous three months, will be excluded from the study.(9) Cricketers experiencing numbness or tingling sensations in the upper extremity will also be excluded.(19) Individuals with associated medical conditions such as cardiovascular or pulmonary diseases will not be considered eligible for participation.(9) Furthermore, subjects with recurrent shoulder dislocations or symptoms of shoulder instability will be excluded from the study.

e. Data Collection Tools

Goniometer (Range of Motion)

Goniometry is a method used by physical therapists to measure how far joints can move (range of motion or ROM), both when assisted and unassisted. A goniometer is a tool that measures angles in joints. This practice is the science of measuring joint ranges in different planes. The term "goniometry" comes from Greek, where "gonia" means "angle" and "metron" means "to measure." The first known goniometer was used by Gemma Frisius, a Dutch physician, to track celestial positions (21)

Intrarater reliability for flexion, extension, and abduction was high (0.94–0.98). For horizontal movements and internal rotation, intertester reliability was low (0.28–0.55), while external rotation was high (0.88–0.90). Intrarater reliability for these movements was also high (0.87–0.99). (22)

Pain (Numeric Pain Rating Scale)

The Numeric Rating Scale (NRS) is a self-report tool for measuring pain intensity in chronic musculoskeletal pain. Patients rate their pain from 0 (no pain) to 10 (worst pain). It can be administered verbally or in writing, making it versatile for different clinical settings. Studies show that the NRS has good to excellent reliability in patients with limb musculoskeletal disorders.

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Shoulder Function (Shoulder Pain and Disability Index)

The Shoulder Pain and Disability Index (SPADI) is a commonly used outcome measure designed to assess shoulder pain and functional disability in outpatient settings. It consists of 13 items divided into two subscales: a 5-item pain subscale and an 8-item disability subscale. Two versions of the SPADI are available, including the original visual analogue scale (VAS) version and a numerical rating scale (NRS) version developed to simplify scoring and administration.(27) The questionnaire was initially developed and tested in male patients presenting with shoulder pain in ambulatory care settings.(28)

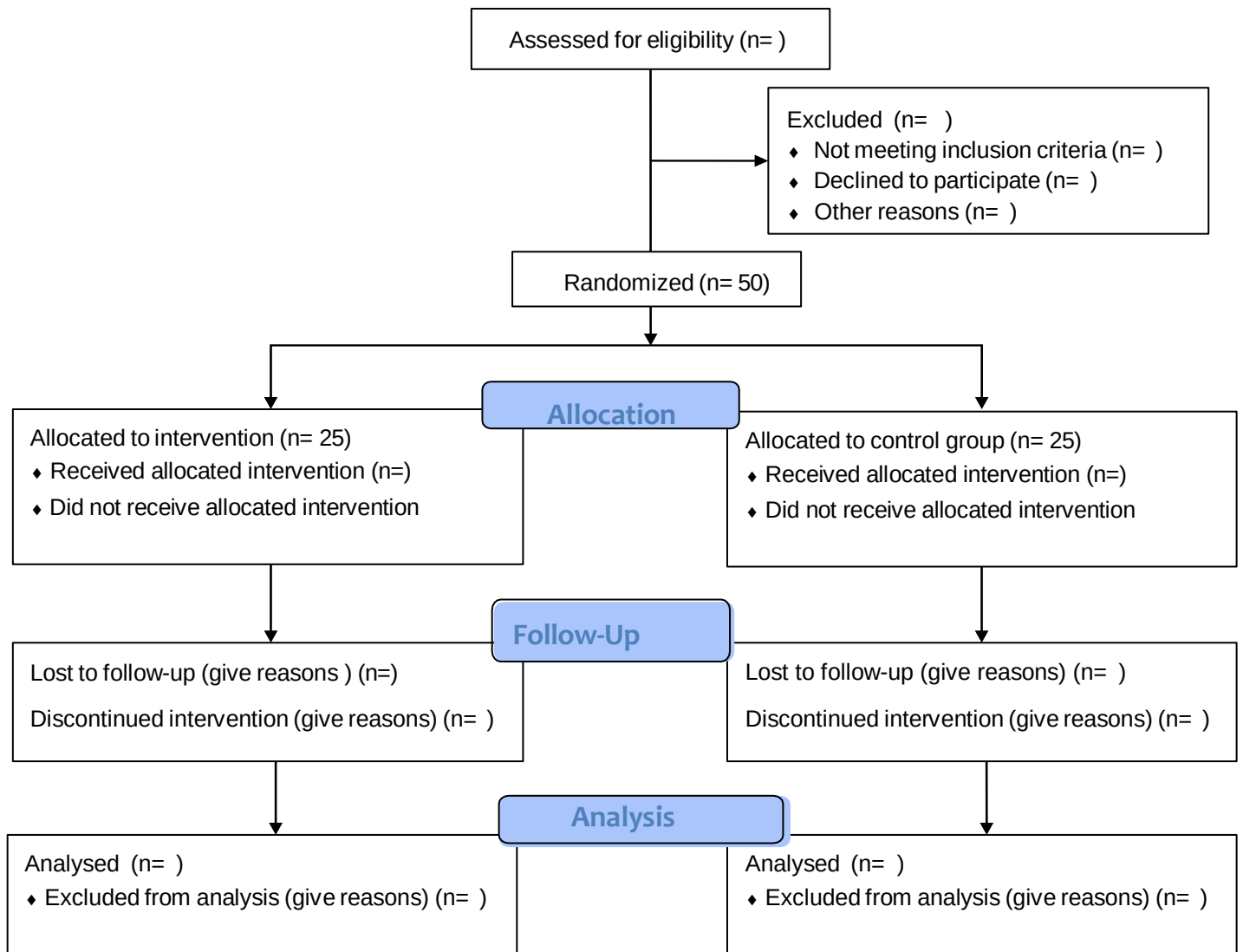
Since its development, the SPADI has been widely used in both primary care and surgical populations, including patients with rotator cuff disorders, osteoarthritis, rheumatoid arthritis, adhesive capsulitis, and shoulder replacement surgery.(29-36) The SPADI has demonstrated strong psychometric properties, including high internal consistency with Cronbach's alpha values generally above 0.90 and excellent reliability with intraclass correlation coefficients (ICC) of 0.89 or higher across various patient populations.(36,37)

The SPADI also demonstrates good construct validity through strong correlations with other shoulder-specific outcome measures.(37–39) Additionally, it is responsive to clinical change over time and can effectively distinguish between improving and worsening patient conditions.(27,29,37) No significant floor or ceiling effects have been reported.(37,39)

The minimal clinically important difference (MCID) for the SPADI is reported to be 8 points, representing the smallest clinically meaningful improvement perceived by patients.(37) The minimal detectable change at the 95% confidence level (MDC95) is 18 points when repeated measurements are obtained over time.(35,40) In this study, SPADI scores will be assessed at baseline, after 3 weeks of intervention, and after completion of the 6-week intervention period.

f. Data Collection Procedures

All participants will first be analyzed according to the eligibility criteria to ensure they meet the requirements for the study. Participants will be allocated to the experimental group or the control group using a simple randomization technique. Fifty identical, opaque envelopes, each containing a pre-assigned group label (i.e, A group and B group), will be carefully shuffled to eliminate sequential predictability and ensure unbiased distribution. The therapist, responsible solely for administering interventions, will access the envelope's content strictly after formal enrollment, preserving allocation concealment throughout the recruitment phase. Participants and outcome assessors remained blinded to group assignments to mitigate performance and detection bias. This methodology adhered to CONSORT guidelines, emphasizing allocation secrecy, procedural transparency, and minimizing bias risks while maintaining the trial's scientific rigor. Participants will be analyzed according to eligibility criteria. To assess pain levels, the Numeric Pain Rating Scale (NPRS) will be used. The range of motion will be measured using a standard Goniometer, and Shoulder Pain and Disability will be evaluated through the SPADI Questionnaire. Measurements will be taken at baseline, at 3 weeks, and at 6 weeks intervention period, with each intervention consisting of three sessions per week, to monitor changes in these parameters over time.



CONSORT DIAGRAM

4.8. Interventions:

Experimental Group

Participants in the experimental group will undergo uncontrolled movement assessment using standardized benchmarks for faulty movement patterns, including a 60° benchmark for medial rotation and a 45° benchmark for lateral rotation without scapular compensation or humeral head translation in supine and standing positions with 90° elbow flexion.(11) A shoulder warm-up consisting of arm circles, shoulder rolls, and overhead reach exercises will be performed in two sets of 10 repetitions with 30 seconds rest between sets. Movement retraining interventions will include passive scapular stabilization, passive glenohumeral stabilization, scapular repositioning, and supported and unsupported correction exercises using visual, tactile, and manual cues.(11) Participants will also receive Mulligan Mobilization with Movement (MWM) using passive dorsal glide techniques (Grade III and IV) for three sets of 10 repetitions combined with active internal rotation of the restricted shoulder, with 30 seconds rest between sets. The intervention will be administered three times per week.

Control Group

Participants in the control group will perform shoulder warm-up exercises including arm circles, shoulder rolls, and overhead reach exercises in two sets of 10 repetitions. Modified sleeper stretching will be performed in a side-lying position on the restricted side with the elbow flexed to 90°, shoulder elevated to 90°, and trunk rotated posteriorly by 20°–30°, combined with passive internal rotation for three sets of 30-second holds and 30 seconds rest between sets.(9) Shoulder internal rotation isometric exercises will be performed in standing for three sets of 10 repetitions with a 5–10 second hold and 30 seconds rest between sets. Participants will additionally receive Mulligan Mobilization with Movement (MWM) using passive dorsal glide techniques (Grade III and IV) for three sets of 10 repetitions with active internal rotation of the restricted shoulder and 30 seconds rest between sets. All interventions will be performed three times weekly

Data Analysis Techniques

To compare the means of the two groups at three time points (baseline, 3 weeks, and 6 weeks) to assess the treatment effect over time, the statistical analysis will be done using IBM SPSS Statistics V.29. Before analysis normality will be tested using Shapiro-Wilk Test and homogeneity of variance will be tested using Levene's Test. A mixed-effects analysis of variance (ANOVA) will be conducted in case of normally distributed data to account for repeated measures and group differences, allowing for the evaluation of interaction effects between time and group. For within-group difference, a paired t-test for parametric data and a Wilcoxon signed-rank test for non-parametric data will be used. To check out and identify specific differences between groups at each time, post-hoc analysis (Turkey's

Test) will be conducted. If $p \leq \alpha$ (e.g., 0.05), reject the null hypothesis (indicating statistical significance). If $p > \alpha$, do not reject the null hypothesis (indicating no statistical significance).

g. Ethical Considerations

- Written informed consent will be taken from all the participants.
- In terms of copyright issues, the author's permission will be taken before the use of study results.
- The subjects will be informed that there are no major disadvantages or risks on the procedure of the study. However, minor bruising or hematoma can occur.
- They will also be informed that they will be free to withdraw at any time during the process of the study.
- The health of patients will be the primary consideration.
- Findings shall be used strictly for scientific publication.
- The confidentiality of the information shall be assured and maintained.

9. REFERENCES

1. Fares MY, Lawand J, Daher M, Suarez JD, Kayepkian T, Koa J, et al. Glenohumeral internal rotation deficit: insights into pathologic, clinical, diagnostic, and therapeutic characteristics. *Clinics in Shoulder and Elbow*. 2024;27(4):505.
2. Schmalzl J, Walter H, Rothfischer W, Blaich S, Gerhardt C, Lehmann L-J. GIRD syndrome in male handball and volleyball players: Is the decrease of total range of motion the turning point to pathology? *Journal of Back and Musculoskeletal Rehabilitation*. 2022;35(4):755-62.
3. Hudson VJ. Evaluation, diagnosis, and treatment of shoulder injuries in athletes. *Clinics in sports medicine*. 2010;29(1):19-32.
4. Tokish JM, Curtin MS, Kim Y-K, Hawkins RJ, Torry MR. Glenohumeral internal rotation deficit in the asymptomatic professional pitcher and its relationship to humeral retroversion. *Journal of sports science & medicine*. 2008;7(1):78.
5. Hellem A, Shirley M, Schilaty N, Dahm D. Review of shoulder range of motion in the throwing athlete: Distinguishing normal adaptations from pathologic deficits. *Current reviews in musculoskeletal medicine*. 2019;12:346-55.
6. Harshbarger ND, Eppelheimer BL, McLeod TCV, McCarty CW. The effectiveness of shoulder stretching and joint mobilizations on posterior shoulder tightness. *Journal of Sport Rehabilitation*. 2013;22(4):313-9.
7. Kisner C, Colby LA. Resistance exercise for impaired muscle performance. *Therapeutic exercise*, 5th ed Philadelphia: FA Davis Company. 2007:147-86.
8. Rockwood CA, Wirth MA, Fehringer EV. Rockwood and Matsen's *The Shoulder E-Book*: Elsevier Health Sciences; 2016.
9. Gharisia O, Lohman E, Daher N, Eldridge A, Shallan A, Jaber H. Effect of a novel stretching technique on shoulder range of motion in overhead athletes with glenohumeral internal rotation deficits: a randomized controlled trial. *BMC Musculoskeletal Disorders*. 2021;22:1-10.
10. van der Linde JA, van Kampen DA, van Beers LW, van Deurzen DF, Terwee CB, Willems WJ. The Oxford Shoulder Instability Score: validation in Dutch and first-time assessment of its smallest detectable change. *Journal of orthopaedic surgery and research*. 2015;10:1-8.
11. Comerford M, Mottram S. *Kinetic Control management of uncontrolled movements*, 2012. First Edition Human Kinetics.
12. Small C. *Kinetic Control–The Management of Uncontrolled Movement*. *Physical Therapy in Sport*. 2013;14(1):68.
13. Kamali F, Ghasempour N, Dehno NS. Immediate effect of combining glenohumeral and

scapulothoracic mobilization with stretching on improving shoulder internal rotation in overhead throwing athletes with glenohumeral internal rotation deficit: A randomized clinical trial study. *Physiotherapy Practice and Research*. 2021;42(2):119-26.

14. Francino G, Moreno-Reyes P, Pastén-Hidalgo W, Contreras S, Espinoza V, Pena C, et al. Comparison of Muscle Energy Technique, Myofascial Release, and Combined Techniques for Glenohumeral Internal-Rotation Deficit. An Interventional Study. *International Journal of Morphology*. 2024;42(3).

15. Ulusahin SB, Duzgun I, Ugurlu M, Ozcakar L. Effects of the stretching program in male volleyball players with posterior shoulder tightness. *Musculoskeletal Science and Practice*. 2024;73:103148.

16. Wilk KE, Hooks TR, Macrina LC. The modified sleeper stretch and modified cross-body stretch are used to increase the shoulder internal rotation range of motion in the overhead throwing athlete. *Journal of orthopaedic & sports physical therapy*. 2013;43(12):891-4.

17. Sudhan M A, Chandran S, Nuhmani S, Ahsan M, Alghadir AH, Khan M. Effects of modified sleeper stretch and modified cross-body stretch on upper limb functions and shoulder ROM in tennis players: a randomized trial. *Scientific Reports*. 2023;13(1):9124.

18. Mine K. Immediate effects of two types of stretching techniques on glenohumeral internal rotation deficit and posterior shoulder tightness; a crossover randomised controlled trial. *Phys Ther Sports Med*. 2017;1:3.

19. Kini KV, Rathod D, Kumar A. Comparison of Muscle Energy Technique vs Mulligan to Improve Gird in District Level Cricket Bowlers. *International Journal of Health Sciences and Research*. 2021;11(5):88-93.

20. Johnson JE, Fullmer JA, Nielsen CM, Johnson JK, Moorman III CT. Glenohumeral internal rotation deficit and injuries: a systematic review and meta-analysis. *Orthopaedic journal of sports medicine*. 2018;6(5):2325967118773322.

21. Gandbhir VN, Cunha B. Goniometer. 2020.

22. Boone DC, Azen SP, Lin C-M, Spence C, Baron C, Lee L. Reliability of goniometric measurements. *Physical therapy*. 1978;58(11):1355-60.

23. Goldsmith ES, Taylor BC, Greer N, Murdoch M, MacDonald R, McKenzie L, et al. Focused evidence review: psychometric properties of patient-reported outcome measures for chronic musculoskeletal pain. *Journal of General Internal Medicine*. 2018;33:61-70.

24. Jensen MP, Karoly P. Self-report scales and procedures for assessing pain in adults. 2011.

25. Da Cunha RA, Costa LOP, Hespanhol LC, Pires RS, Kujala UM, Lopes AD. Translation, cross-cultural adaptation, and clinimetric testing of instruments used to assess patients with

patellofemoral pain syndrome in the Brazilian population. *Journal of orthopaedic & sports physical therapy*. 2013;43(5):332-9.

26. Sendlbeck M, Araujo EG, Schett G, Englbrecht M. Psychometric properties of three single-item pain scales in patients with rheumatoid arthritis seen during routine clinical care: a comparative perspective on construct validity, reproducibility and internal responsiveness. *RMD open*. 2015;1(1):e000140.

27. Williams Jr JW, Holleman Jr DR, Simel D. Measuring shoulder function with the Shoulder Pain and Disability Index. *The Journal of Rheumatology*. 1995;22(4):727-32.

28. Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. *Arthritis & Rheumatism: Official Journal of the American College of Rheumatology*. 1991;4(4):143-9.

29. Beaton DE, Richards RR. Measuring the function of the shoulder. A cross-sectional comparison of five questionnaires. *JBJS*. 1996;78(6):882-90.

30. MacDermid JC, Solomon P, Prkachin K. The Shoulder Pain and Disability Index demonstrates factor, construct, and longitudinal validity. *BMC Musculoskeletal Disorders*. 2006;7:1-11.

31. Ekeberg OM, Bautz-Holter E, Tveitå EK, Keller A, Juel NG, Brox JI. Agreement, reliability, and validity in 3 shoulder questionnaires in patients with rotator cuff disease. *BMC Musculoskeletal Disorders*. 2008;9:1-9.

32. Christie A, Dagfinrud H, Garratt AM, Osnes HR, Hagen KB. Identification of shoulder-specific patient acceptable symptom state in patients with rheumatic diseases undergoing shoulder surgery. *Journal of Hand Therapy*. 2011;24(1):53-61.

33. Staples MP, Forbes A, Green S, Buchbinder R. Shoulder-specific disability measures showed acceptable construct validity and responsiveness. *Journal of Clinical Epidemiology*. 2010;63(2):163-70.

34. Tveitå EK, Ekeberg OM, Juel NG, Bautz-Holter E. Responsiveness of the shoulder pain and disability index in patients with adhesive capsulitis. *BMC Musculoskeletal Disorders*. 2008;9:1-8.

35. Angst F, Goldhahn J, Pap G, Mannion A, Roach K, Siebertz D, et al. Cross-cultural adaptation, reliability, and validity of the German Shoulder Pain and Disability Index (SPADI). *Rheumatology*. 2007;46(1):87-92.

36. Hill CL, Lester S, Taylor AW, Shanahan ME, Gill TK. Factor structure and validity of the shoulder pain and disability index in a population-based study of people with shoulder symptoms. *BMC Musculoskeletal Disorders*. 2011;12:1-6.

37. Roy JS, MacDermid JC, Woodhouse LJ. Measuring shoulder function: a systematic review

of four questionnaires. *Arthritis Care & Research: Official Journal of the American College of Rheumatology*. 2009;61(5):623-32.

38. Paul A, Lewis M, Shadforth M, Croft P, Van Der Windt D, Hay E. A comparison of four shoulder-specific questionnaires in primary care. *Annals of the rheumatic diseases*. 2004;63(10):1293-9.

39. Bot S, Terwee C, Van der Windt D, Bouter L, Dekker J, De Vet H. Clinimetric evaluation of shoulder disability questionnaires: a systematic review of the literature. *Annals of the rheumatic diseases*. 2004;63(4):335-41.

40. Schmitt JS, Di Fabio RP. Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *Journal of Clinical Epidemiology*. 2004;57(10):1008-18.

