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ABSTRACT

Objectives: To determine the criterion-related validity of a new novel method of measuring shoulder hand behind back (HBB) range of motion (ROM) for evaluating pain and disability in people with shoulder pain and movement impairment.

Methods: Shoulder ROM, pain, fear-avoidance beliefs, and disability were evaluated in 60 people (aged 35-70 years, 31 male) with chronic unilateral shoulder dysfunction (mean duration 15.73 weeks). Shoulder HBB ROM was measured with a bubble inclinometer. Correlations were sought between HBB ROM and other shoulder movements, as well as scores recorded on the Shoulder Pain and Disability Index (SPADI), Visual Analogue pain Scale (VAS), fear-avoidance beliefs Questionnaire (FABQ), and duration of symptoms.

Results: Restriction of HBB movement was significantly correlated with SPADI total disability score ($r = 0.39$, $P < 0.01$), Flexion ROM ($r = 0.30$, $P < 0.05$), Abduction ROM ($r = 0.39$, $P < 0.01$), and External Rotation ROM ($r = 0.60$, $P<0.01$). Other variables were not significantly correlated with HBB ROM. Multiple linear regression analysis indicated that the variance in HBB ROM was explained by the SPADI disability sub-score ($p= 0.01$), but not by the VAS pain score ($p=0.05$), FABQ score ($p= 0.65$), or duration of symptoms ($p= 0.73$). The FABQ score was not explained by limitation in HBB ROM and shoulder movements.

Conclusion: These findings indicate that this new and novel method of measuring HBB ROM may be incorporated as an additional functional outcome measure in the evaluation of patients with shoulder disorders.

Key words: Hand behind back; Inclinometer; Shoulder; Validity

INTRODUCTION

Musculoskeletal problems affecting the shoulder are common in Indian rural as well as urban areas with life time incidence reported as 15.6%.[1,2,3] The one-year prevalence of shoulder complaints in the general population was reported to be as high as 46.7%.[4] Clinically, patients with shoulder pain and movement restriction show inability to reach overhead, behind their head or their back, all of which interferes with daily activities.[5] Such limitations also affect psychological and social functioning.[6,7]

The functional deficits seen in various shoulder pathologies are in part determined by evaluating routinely measured cardinal plane physiological movements, as well as through functional evaluation.[8] These functional assessments commonly utilize self-reports of functional status[9] and physical measures[10] which are also used as outcome measures in clinical practice as well as in research. Although self-reports of functional status have been shown to be valid and reliable,[11] it has been suggested that more specific outcome measures are crucial for determining treatment success in management of shoulder problems.[9] The choice of measure should be based on a variety of factors including the patient population.[12] Physical measures of shoulder functional impairment include hand behind neck[10] and hand behind back (HBB) measures.[13,14,15,16,17,18]

Shoulder HBB range of motion (ROM) is reported as an important functional deficit when evaluating activities such as dressing and toileting[19] and has been extensively studied.[16,18,20,21] Satpute et al (2015) demonstrated that improving HBB ROM improved shoulder function and pain in patients with non-specific shoulder pain and movement impairment.[22]

In the past, the movement of HBB has often been used interchangeably with internal rotation, with both thought to measure the same construct. However, previous research indicates a poor relationship between these two measures and hence it has been suggested that HBB ROM should be assessed in addition to the more usual physiological measures of shoulder movement in the cardinal planes.[16,23] The various methods proposed to measure HBB ROM usually involve the use a tape measure or a modified standard goniometer.[21] Although the tape measure method for measuring HBB ROM that utilizes the posterior superior iliac spine (PSIS) as a reference point has been shown to have excellent reliability,[18] this method may not be suitable for patients in some cultures where skin exposure is not allowed. Furthermore, this method cannot be used in patients with severe restriction of HBB movement, when they are unable to even reach the sacrum for example in conditions such as adhesive capsulitus.[24] To overcome this issue, a novel method of measuring HBB ROM has been proposed utilizing a bubble inclinometer that should be acceptable in multicultural countries as it does not require skin exposure and also provides ROM in degrees. Although HBB movement usually comprises a combination of shoulder extension, internal rotation/adduction, elbow flexion, forearm pronation and various scapular movements, the new method, for measurement purpose measures only elbow flexion as a proxy for HBB ROM. In this measurement method the humerus is maintained vertical by the subject’s side while they reach up behind their back and elbow flexion ROM is recorded.

For goniometry to provide meaningful information measurements must be valid, reliable and should represent the true value of the variable of interest.[25] Furthermore, criterion-related validity of the measurement is an important consideration[26] to justify the use of the test in research as well as in clinical practice.

The purpose of this study was to assess the criterion-related validity of this new novel method of measuring HBB ROM. The primary hypothesis was restriction of HBB ROM will correlate with shoulder related disability and shoulder movement in other planes. In addition, Lentz (2009) demonstrated that pain, pain-related fear is one of the strong predictors of shoulder disability.[27] Thus the secondary hypothesis was that fear-avoidance behavior will correlate with shoulder disability, pain and impairment of shoulder ROM.

METHODS

Study Design

This single measure, cross-sectional study design investigated the criterion-related validity of a novel method of measuring HBB ROM in patients with shoulder pain and movement impairment..Comparisons of ROM in this new method with traditional tape methods of measuring HBB movement were not carried out due to cultural issues associated with skin exposure.

Subjects

Subjects were recruited from the physiotherapy outpatient department of **XXX** between November 2014 and April 2015, referred by orthopedic surgeons with a provisional diagnosis of musculoskeletal shoulder pain disorders based on routine evaluation and investigations which were carried out in a typical Indian Orthopaedic outpatient department. These subjects were evaluated by an experienced physiotherapist and included if they were aged 18-70 years with a history of acute or chronic shoulder pain and associated movement restriction. Subjects were excluded if they had elbow, forearm or wrist joint pathology, a history of dislocation of the glenohumeral or acromioclavicular joint, recent shoulder surgery or fracture, bilateral shoulder involvement, recent cardiac surgery, chronic regional pain syndrome, malignancy, infection, or upper motor neuron lesion.

A total of 60 subjects were enrolled in the study. The flow of subjects through the study is illustrated in Figure 1 with their medical diagnosis presented in Table 1. The sample size was based on eight predictor variables in the regression analysis, with α=0.05, power of 0.8 and effect size of 0.5 requiring a sample size of at least 40.

Procedure

All subjects who fulfilled the inclusion criteria and who volunteered to participate in this study were required to provide written informed consent. Demographic data of age, gender, weight, height and baseline parameters of pain intensity during maximal HBB movement evaluated on the 10 cm Visual Analogue Scale (VAS),[28] disability on the Shoulder Pain and Disability Index (SPADI)[29] and symptom duration were recorded. Psychological factors were measured with the Fear Avoidance Beliefs Questionnaire (FABQ).[30]

The SPADI is a self-administered questionnaire, developed for use in an outpatient setting with two sub-scales pain and function.[29] The numerical rating scale (NRS) version of SPADI was used.[31] The SPADI is a responsive and valid tool to measure pain and functional status of the shoulder region for current status and change over time.[11,32,33] The ICC for the disability subscale ranges from 0.57 to 0.84,[34] indicating moderate reliability. When the SPADI is administered before treatment and then at discharge, the minimum detectable change (MDC) is 18 points.[35]

The FABQ was used to predict and quantify fear-avoidance behavior. The two sub-scales of FABQ contain a four-item FABQ physical activity component with minimum score of zero and maximum of 24; and a seven item FABQ work component with minimum score of zero and maximum of 42. These two sub-scales are added as per the instructions of developers to give a final score. Higher scores indicate higher levels of fear-avoidance behavior. Initially the FABQ was designed to measure the fear-avoidance beliefs specific to LBP.[30] The FABQ was modified to make it suitable to measure the fear-avoidance beliefs specific to shoulder and / or elbow pain. An intra rater reliability analysis for this FABQ work subscale (ICC = 0.52) and FABQ physical activity subscale (ICC = 0.59) was reported as low reliability.[36]

Physiological shoulder movements (Table 2) were measured using a universal goniometer with one-degree increments with the subject positioned in supine. Active assisted shoulder flexion ROM with passive overpressure at the end of movement was measured by determining the angle between the mid axillary line and the lateral midline of the humerus aligning a fulcrum at the greater tuberosity.[25] Mullaney et al (2010) reported the reliability of this method as excellent. Intra-rater and inter-rater reliability ranges from 0.96 to 0.97 and 0.88 to 0.93 respectively. The MDC for shoulder ROM is at least six degrees with standard error of measurement (SEM) 15 degrees.[37] Passive shoulder abduction ROM was measured with the humerus in neutral rotation, by measuring the angle between the line parallel to midline of the sternum and anterior midline of the humerus aligning a fulcrum at the anterior aspect of the acromion process.[25] Intra-rater (ICC =0.98) and inter-rater (ICC = 0.87) reliability for this measurement is excellent.[38] Passive shoulder external and internal rotation ROM was measured by determining the angle between the line parallel to floor and ulnar border aligning a fulcrum at the olecranon process.[25] Rotation was measured at 90 degrees abduction with the scapula stabilized. For external rotation, this measurement method has highly reliability (ICC =0.99).[39] Although the reliability of measuring internal rotation in this way was not reported, Cools et al reported good to excellent reliability for measuring internal rotation irrespective of shoulder position.[40] The end point for all physiological movement was when pain limited the movement, with the average of three trials recorded.

Following this, the functional measure of HBB ROM was measured by the physiotherapist blinded to baseline evaluation of pain, ROM and functional measures. HBB ROM was measured on the affected side using a bubble inclinometer (Baseline, USA) placed on the lateral aspect of radius proximal to the radial styloid process (Figure 2). This device consisted of a fluid-filled chamber covered with movable 360-degree scale divided into one degree increments. The procedure was explained and a demonstration was given to familiarize the subject with the required movement. With the subject standing, they were instructed to actively move their HBB, as far as possible keeping the dorsum of their hand in contact with their back while avoiding compensatory scapular elevation or spine movement. Once crossed sacrum, subjects were asked to trace their thumb up their spine along the line of the spinous processes. Incorrect movement was corrected by the examiner by verbal and tactile clues before final measurements were taken. The end-position of the arm was supported and stabilized passively by the examiner while measurements were taken from the bubble inclinometer. End of range occurred, when either pain limited the movement or the person was unable to move further even with encouragement. The difference between the initial starting position (zero degree) with the arm by the side, elbow in full extension, forearm pronation, and the maximum possible HBB position was measured with the bubble inclinometer (Figure 1).

An average of three trials was taken which was then considered as the final HBB ROM in degrees. We have previously calculated the reliability for this method in a similar patient population. Intra-rater (ICC= 0.97, 95% CI 0.95- 0.99) and inter-rater reliability (ICC= 0.96, 95% CI 0.91- 0.98) values indicate excellent reliability with SEM and MDC of two and six degrees respectively.[41]

The assessment was completed without preparatory warm up or familiarization trials in a single session by a physical therapist with 12 years of experience in musculoskeletal practice. The protocol for this study was approved by the Research Ethics Committee of the **XXX**.

STATISTICAL ANALYSIS

The Statistical Package for Social Sciences (SPSS 19) software was used for statistical analysis. Descriptive statistics were calculated for demographic, ROM impairment, pain with maximum HBB movement, and self-report questionnaire data. Correlations were calculated between each ROM impairment measure, demographic variable, FABQ score and SPADI function sub-score using Pearson correlation analysis. Finally, separate multiple linear regression analyses were used to determine which variables best predicted the variability in shoulder HBB ROM, VAS pain score with maximal HBB movement, and shoulder disability identified by the SPADI function sub-score. Prior to analyses, all assumptions for the use of multiple linear regression analysis were assessed.

RESULTS

The study sample comprised 31 (51.7%) males and 29 (48.3%) females. Descriptive statistics and mean impairment measures are presented in Table 2. Symptom duration was more than 3-weeks in 35% of subjects and more than 12-weeks in 61.7% of subjects thus indicating a mix of acute and chronic disorders.

Correlation coefficients among variable are listed in Table 3. HBB ROM on the impaired side showed a significant univariate correlation with SPADI total disability score (0.39, P < 0.01), flexion ROM (r = 0.30, P < 0.05), abduction ROM (0.39, P < 0.01), and external rotation ROM (r = 0.51, P<0.01). Other variables were not significantly correlated.

Prior to interpreting the results of the multiple linear regression analysis, several assumptions were evaluated and found to be acceptable including normality, linearity, homoscedasticity, multivariate outliers and tolerance. The results of the multiple linear regression analysis with unstandardized (*B)* and standardized (β) regression coefficients as well as t and *pare* presented in table 4.

With HBB ROM as the dependent variable, the R^2 values suggest that 20.2% of the variance in HBB ROM can be explained by a combination of VAS Pain score with maximal HBB movement, FABQ score, SPADI function sub-score, and duration of symptoms. This was significant ($F_{(4, 53)} = 3.36$, $p = 0.02$) with examination of t-values indicating that only SPADI disability sub-score (t = -2.63, $p = 0.01$) contributed to the prediction of HBB ROM. In contrast to the SPADI score, the VAS pain score was not significant (t = -1.96, p = 0.05).

With HBB ROM as the dependent variable, the R^2 values suggest that 28.1% of the variance in HBB ROM can be explained by the combination of shoulder flexion, abduction, internal rotation, and external rotation ROM values. This was highly significant ($F_{(4, 55)} = 5.36$, $p< 0.01$) with examination of t-values indicating that only external rotation ROM (t = 2.52, $p = 0.02$) contributed to the prediction of HBB ROM.

With VAS Pain score at maximal HBB position as the dependent variable, the R^2 values suggest that only 14.6% of the variance in the VAS Pain score can be explained by the combination of shoulder flexion, abduction, internal rotation, external rotation, and HBB ROM values. This was not significant ($F_{(5, 53)} = 1.81$, p =

0.13) with examination of t-values indicating that no independent variables were significant.

With SPADI disability score as the dependent variable, the R^2 values suggest that only 23% of the variance in the SPADI disability score can be explained by the combination of shoulder flexion, abduction, internal rotation, external rotation, and HBB ROM values. This was significant ($F_{(5, 54)} = 3.22$, $p = 0.01$) with examination of t-values indicating that only flexion ROM (t = -2.08, $p = 0.04$) contributed to the prediction of SPADI disability score.

In a clinical context, these analyses suggest that HBB ROM was partly explained by the SPADI function sub-score and external rotation ROM . Likewise shoulder disability identified by the SPADI function sub-score was only partly explained by an index of shoulder flexion ROM.

DISCUSSION

The results of this study demonstrated that in patients with shoulder pain and movement restrictions the functional measure of HBB was significantly correlated with shoulder disability as measured with the SPADI function sub-score providing evidence for its criterion validity. There was a significant correlation between the new method of measuring impairment of shoulder HBB ROM and impairment of shoulder physiological movements of flexion, abduction and external rotation, but not with impairment of internal rotation measured in abduction. This was somewhat unexpected, as the movement of HBB is thought to be associated with shoulder internal rotation. In addition to shoulder movements, variance in HBB ROM was also correlated with VAS Pain score, FABQ score, SPADI function sub-score, and duration of symptoms. The secondary hypothesis regarding correlation between fear-avoidance behavior with shoulder movement impairment was rejected.

An important finding from our study was the association between HBB ROM and disability measured by the SPADI function sub- score but not with the pain sub score. We did not incorporate the SPADI Pain sub score in the analysis, as this measure does not directly include factors related to pain associated with the movement of HBB.[29] We chose instead to use the VAS pain score during maximum HBB movement. However, we did not find a significant correlation between HBB ROM and pain ($p = 0.05$). The SPADI disability subscale has two items (out of 8) that relate to the movement of HBB.[29] This suggests that at least 25% of the disability component score can be accounted for by the loss of HBB movement. The study's finding of 20% of the variance in HBB ROM being explained by the disability subscale of SPADI is therefore not surprising. Moreover,Engebretsen et al (2010) also demonstrated significant correlation between HBB and pain subscale ($p=0.01$) and function subscale ($p< 0.001$) of SPADI in patients with subacromial pain.[42] This finding provides evidence for the validity in using the new novel method of measuring HBB to measure disability in patients with shoulder pain and movement restriction. Clinically, HBB movement restriction is typically seen in patients with acromioclavicular and glenohumeral osteoarthritis, bursitis, and primary or secondary adhesive capsulitis.[24] Moreover, movement impairment is present in patients with capsular and non-capsular patterns of movement restriction[43] and is thus a commonly seen occurrence in patients referred for physiotherapy for shoulder pain. This was true for our sample of patients referred through a typical orthopaedic outpatient department.

The finding of lack of association between range of shoulder internal rotation in abduction and range of HBB is consistent with previous studies.[16,20,23] Wakabayashi et al(2006) reported that in normal subjects there is a mean range of 48.4˚ shoulder internal rotation, which occurs when the hand reaches the sacrum during the movement of HBB.[23] Until this point, internal rotation range dominates; but thereafter the maximum contribution is by elbow flexion of more than 100°.[20,23] This indicates that slightly more than half the available range of internal rotation is utilized during HBB, complemented by a larger range of elbow flexion. This might explain the poor relationship between HBB ROM and shoulder internal rotation. In addition, the movement of HBB is a composite of movements occurring at the glenohumeral and scapulothoracic joints. Glenohumeral movement occurs first, peaking at the point when the hand reaches the buttock, followed there after by scapulothoracic movement.[20] Hence, this point may explain the lack of correlation we found between internal rotation and HBB. Future studies using radiologic analysis are recommended to further evaluate HBB ROM as measured by the new method of measurement for greater understanding of this complex movement.

The present study is first to correlate loss of HBB movement with other commonly assessed shoulder movements in patients with shoulder pain and movement restriction. Wakabayashi et al (2006) reported that shoulder abduction increased significantly in the initial phase of the normal movement of HBB until the hand reaches the buttock position[23]. This may explain the significant correlation between the restricted abduction and HBB movement, although the range of abduction occurring during HBB is relatively small in amplitude.

The strong correlation seen between HBB and external rotation movements could be attributed to the subjects included in our study. The most frequent diagnosis was adhesive capsulitis, moreover the mean duration of symptoms was 15.7 weeks, highlighting the chronic nature. External rotation restriction is a common movement limitation seen in patients with similar pain disorders.[44] Based on the findings of our study it is reasonable to deduce that clinically HBB movement should also be assessed even in patients with loss of external rotation ROM for some determination of potential pain, impairment and disability.

The importance of assessing HBB movement is demonstrated in a recent study under taken by our group. Patients with shoulder pain and non-specific shoulder movement impairment were selected and treated with a course of Mulligan HBB mobilization with movement.[22] The movement of HBB was specifically targeted in this intervention, following which there was significant and clinically important improvement in HBB ROM, pain intensity and disability scores as measured with SPADI showing a mean difference of 16.20 (3.99) cm, 5.31(1.80) cm and 40.63 (6.47) respectively. Moreover, HBB movement is an integral part of activities of daily living such as dressing and toileting. Where measurement of this movement by traditional means is not possible, the new method can be implemented easily while respecting privacy and cultural values.

Measuring shoulder ROM is one of the most common forms of evaluation for shoulder disorders.[45] Previous studies have identified significant correlations between ROM impairment and disability in a range of musculoskeletal disorders including the cervical spine,[46] hip and knee.[47] The strength of correlation between shoulder ROM and the SPADI disability subscale are presented in Table 3. These findings demonstrate moderately strong negative correlations between SPADI scores and shoulder ROM, particularly flexion, abduction and external rotation. These results are generally in accordance with Hill et al (2011) who reported on the construct validity of the SPADI in people with shoulder disorders, with exception of external rotation movement.[33] These findings suggest shoulder flexion, abduction and external rotation ROM impairment also needs be considered, in addition to functional measure of HBB ROM, when assessing patients with shoulder dysfunction. Despite these findings, a recent study by Lee et al (2015) demonstrated no correlation between shoulder ROM restriction and pain which supports our findings of a lack of correlation between HBB ROM and pain (p = 0.05). [48]

In contrast to other forms of musculoskeletal dysfunction such as in low back and neck pain, there was a low correlation between SPADI disability sub-scale and fear-avoidance behavior measured by the FABQ (r= 0.30). In addition, fear-avoidance behavior was neither explained by limitation in HBB ROM nor by limitation of any physiological movements, thus rejecting our secondary hypothesis. These results are in partial accordance with previous research, which reported that pain-related fear as measured by the Tampa Scale of Kinesiophobia partially contributed to shoulder disability but with no correlation with shoulder physiological movements.[27]

The study findings also indicate that there was no correlation between pain with maximal HBB movement and FABQ (r = -0.14). Despite this, George et al (2008) previously reported that biopsychosocial factors do influence shoulder pain.[49] The possible explanation for above findings could be the lack of validity and reliability of FABQ for its use in upper extremity disorders[37]

Limitations

While interpreting these results, readers should be aware that subjects were excluded if they presented with lack of physiological movement impairment, thus the study's findings may not be valid for all patients with shoulder problems such as a partial thickness rotator cuff tear. In addition, this new measurement method may not be suitable for patients presenting with shoulder dysfunction who also have associated movement restriction at the elbow or forearm. Another potential limitation was the use of the FABQ for measuring fear avoidance as its validity and reliability has not been demonstrated in the upper extremity.

CONCLUSION

A new novel method of measuring shoulder HBB ROM in patients with shoulder pain and movement impairment appears to have moderate criterion validity, in that shoulder functional loss is correlated with HBB ROM. This method should be considered as an alternative where there are challenges in measuring HBB due to restrictions in undressing.

REFERENCES

1. Sharma R, editor. Epidemiology of Musculoskeletal Conditions in India. New Delhi, India: ICMR bull; 2012.
2. *Moom R K, Sing L P, Moom N.* Prevalence of Musculoskeletal Disorder among Computer Bank Office Employees in Punjab (India): A Case Study. Procedia Manufacturing 2015; 3: 6624-31.
3. Singh S, Gill S, Mohammad F, Kumar S, Kumar D, Kumar S. Prevalence of shoulder disorders in tertiary care centre. *Int J Res Med Sci. 2015; 3(4):917-20.*
4. Luime JJ, Koes BW, Hendriksen IJ, Burdorf A, Verhagen AP, Miedema HS, et al. Prevalence and incidence of shoulder pain in the general population; a systematic review. Scand J Rheumatol 2004; 33: 73-81.
5. Kisner C and Colby L A. Therapeutic Exercise Foundations and Techniques. 5th edn. Philadelphia, F. A. Davis Company, Chapter 17, The shoulder girdle 2007; 489.

6. Largacha M, Parsons IM 4th, Campbell B, Titelman RM, Smith KL, Matsen F 3rd. Deficits in shoulder function and general health associated with sixteen common shoulder diagnoses: a study of 2674 patients. J Shoulder Elbow Surg 2006; 15: 30-9.
7. Badcock LJ, Lewis M, Hay EM, McCarney R, Croft PR. Chronic shoulder pain in the community: a syndrome of disability or distress? Ann Rheum Dis 2002; 61: 128–31.
8. Roe Y, Soberg HL, Bautz-Holter E, Ostensjo S. A systematic review of measures of shoulder pain and functioning using the International classification of functioning, disability and health (ICF). BMC Musculoskelet Disord 2013; 14:73.
9. Michener LA, Leggin BG. A review of self-report scales for the assessment of functional limitation and disability of the shoulder. J Hand Ther 2001;14: 68-76.
10. Yang J, Lin j. Reliability of function-related tests in patients with shoulder pathologies. J Orthop Sports Phys Ther 2006; 36:572-76.
11. Mac Dermid JC, Solomon P, Prkachin K. The shoulder pain and disability index demonstrates factor, construct and longitudinal validity. BMC Musculoskelet Disord 2006; 7:12.
12. Stiller J, Timothy L. Outcomes measurement of upper extremity function. Athl Ther Today 2005; 10: 24-5.
13. Hayes K, Walton JR, Szomor ZL, Murrell GAC. Reliability of five methods for assessing shoulder range of motion. Aust J Physiother 2007; 47:289 -94.

14. Edwards T, Bostick R, Greene C, Baratta R, Drez D. Interobserver and intraobserver reliability of the measurement of shoulder internal rotation by vertebral level. J Shoulder Elbow Surg 2002; 11(1): 40-2.
15. Hoving JL, Buchbinder R, Green S, Forbes A, Bellamy N, Brand C, et al. How reliably do rheumatologists measure shoulder movement? Ann Rheum Dis 2002; 61: 612-16.
16. Ginn KA, Cohan ML, Herbert RD. Does hand-behind-back range of motion accurately reflect shoulder internal rotation? J Shoulder Elbow Surg 2006; 15(3): 311-14.
17. Green S, Buchbinder R, Forbes A, Bellamy N. A standardized protocol for measurement of range of movement of the shoulder using the Plurirneter-V inclinometer and assessment of its intrarater and interrater reliability. Arthritis Care Res 1998; 11(1): 43-52.
18. Van den Dolder P A, Ferreira P H, Refshauge K. Intra- and inter-rater reliability of a modified measure of hand behind back range of motion. Man Ther 2014; 19: 72-76.
19. Croft P, Pope D, Zonca M, O'Neill T, Silman A. Measurement of shoulder related disability: results of a validation study. Ann Rheum Dis 1994; 53: 525-28.
20. Mallon WJ, Herring CL, Sallay PI, Moorman CT, Crim JR. Use of vertebral levels to measure presumed internal rotation at the shoulder: a radiographic analysis. J Shoulder Elbow Surg 1996; 5: 299–306.
21. Sraj S. Internal Rotation Behind-the-Back Angle: A Reliable angular measurement for Shoulder Internal rotation behind the back. Sports Health 2015; 7:299-302.

22. Satpute KH, Bhandari P, Hall T. Efficacy of hand behind back mobilisation with movement for shoulder pain and movement impairment: a double blind randomised controlled trial. J Manipulative Physiol Ther 2015; 38: 324-34.
23. Wakabayashi I, Itoi E, Minagawa H, Kobayashi M, Seki N, Shimada Y, et al. Does reaching the back reflect the actual internal rotation of the shoulder? J Shoulder Elbow Surg 2006, 15: 306-10.
24. Kelley MJ, Shaffer MA, Kuhn JE, Michener L A, Seitz AL, Uhl T L, et al. Shoulder Pain and Mobility Deficits: Adhesive capsulitis clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. J Orthop Sports Phys Ther 2013;43(5):A1-A31.
25. Norkin CC, White DJ. Measurement of joint motion: A guide to goniometry. 3rd edn. Philadelphia, F.A., Davis Co, chapter 4, The shoulder 2004; 70-73.
26. Gajdosik RL, Bohannon RW. Clinical measurements of range of motion: Review of goniometry emphasizing reliability and validity. Phys Ther 1987; 67(12): 1867–72.
27. Lentz T, Barabas J, Day T, Bishop M, George S. The Relationship of Pain Intensity, Physical Impairment, and Pain-Related Fear to Function in Patients With Shoulder Pathology. J Orthop Sports Phys Ther 2009; 39(4): 270-77.
28. Hawker G, Mian S, Kendzerska T, French M. Measures of adult pain. Arthritis Care Res 2011; 63: 11S240–52.
29. Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. Arthritis Care Res 1991; 4(4):143-49.

30. Waddell G, Newton M, Henderson I, Somerville D, Main CJ A. Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. Pain 2006; 52:157-68.
31. Williams JW, Holleman DR, Simel DL. Measuring shoulder function with the Shoulder Pain and Disability Index. J Rheumatol 1995; 22(4):727-32.
32. Angst F, Goldhahn J, Drerup S, Aeschlimann A, Schwyzer HK, Simmen BR: Responsiveness of six outcome assessment instruments in total shoulder arthroplasty. Arthritis Rheum 2008; 59(3):391-98.
33. Hill C, Lester S, Taylor A, Shanahan M, Gill T. Factor structure and validity of the shoulder pain and disability index in a population-based study of people with shoulder symptoms. BMC Musculoskelet Disord 2011; 12-8.
34. Bot SD, Terwee CB, van der Windt DA, Bouter LM, Dekker J, de Vet HC. Clinimetric evaluation of shoulder disability questionnaires: a systematic review of the literature. Ann Rheum Dis 2004; 63: 335–41.
35. Schmitt JS, Di Fabio RP. Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. J ClinEpidemiol 2004; 57(10):1008-18.
36. Inrig T, AmeyB, Borthwick C, Beaton D. Validity and reliability of the Fear Avoidance Beliefs Questionnaire (FABQ) in workers with upper extremity Injuries. J Occup Rehabil 2012; 22: 59–70.
37. Mullaney M J, McHugh MP, Johnson CP, Tyler TF. Reliability of shoulder range of motion comparing a goniometer to a digital level. Physiother Theory Pract 2010; 26(5): 327–33.
38. Riddle DL, Rothstein JM, Lamb RL. Goniometric reliability in a clinical setting. Phys Ther 1987; 67: 668–73.

39. Johnson AJ, Godges JJ, Zimmerman GJ, Ounanian LL. The effect of anterior versus posterior glide joint mobilization on external rotation range of motion in patients with shoulder adhesive capsulitis. J Orthop Sports Phys Ther 2007; 37: 88-99.
40. Cools A M, Wilde L D, Tongel A, ceyssens C, Ryckewaert R, cambier D C. Measuring shoulder external and internal rotation strength and range of motion: comprehensive intra-rater and inter-rater reliability study of several testing protocols. J Shoulder Elbow Surg 2014; 23: 1454–61.
41. Satpute, Hall T, Senthil Kumar, Deodhar A. A new method of measuring shoulder hand behind back movement: Reliability, values in symptomatic and asymptomatic people, effect of hand dominance, and side-to-side variability. Physiother Theory Pract 2015; (Accepted for publication).
42. EngebretsenK, Grotle M, Bautz-Holter E, Ekeberg O M,Brox J I. Determinants of the shoulder pain and disability index in patients with subacromial shoulder pain. JRehabil Med. 2010; 42: 499–505.
43. Rundquist PJ, Anderson DD, Guanche CA, Ludewig PM. Shoulder kinematics in subjects with frozen shoulder. Arch Phys Med Rehabil 2003; 84:1473-79.
44. Neviaser AS, Hannafin JA. Adhesive capsulitis: a review of current treatment. Am J Sports Med 2010; 38: 2346-56.
45. Roy J S, MacDermid J C, Boyd KU, Faber KJ, Drosdowech D, Athwal G S. Rotational strength, range of motion, and function in people with unaffected shoulders from various stages of life. Sports Med Arthrosc Rehabil Ther Technol 2009; 1:4.

46. Hermann K and Reese c. Relationships among selected measures of impairment, functional limitation, and disability in patients with cervical spine disorders. Phys Ther 2001; 81:903-12.

47. Steultjens M P M, Dekker J, Baar M E, Oostendrop R A B, Bijilsma J W J. Range of joint motion and disability in patients with osteoarthritis of knee or hip. Rheumatology 2000; 39: 955- 61.

48. Lee SY, Lee KJ, Kim W, Chung SG. Relationships between capsular stiffness and clinical features in adhesive capsulitis of the shoulder. 2015;7(12):1226-34.

49. George SZ, Wallace MR, Wright TW, Moserc M W., Greenfield W H, Sackb B K, et al. Evidence for a biopsychosocial influence on shoulder pain: pain catastrophizing and catechol-O-methyltransferase (COMT) diplotype predict clinical pain ratings. Pain 2007;136: 53-61.

Table 1: Medical diagnoses of participants included in the study

Diagnosis	**No. of Subjects**
Tendinitis	7
Rotator cuff degeneration	12
Adhesive capsulitis	22
Arthritis	2
Bursitis	12
No diagnosis	5

Table 2: Descriptive statistics and mean range of motion, pain and disability measures of participants included in the study

Characteristics	**MEAN (SD)**
Age (years)	55.70 (8.73)
Weight (kg)	61.78 (13.10)
Height (cm)	158.81 (14.79)
Symptom duration (weeks)	15.73 (11.20)
Pain with maximum HBB movement (VAS)	6.80 (1.46)
SPADI pain subscale	29.73 (6.70)
SPADI function subscale	40.83 (10.23)
SPADI total score	70.56 (15.57)
FABQ score	59.42 (11.00)
Flexion symptom side°	116.30 (24.58)
Abduction symptom side°	68.10 (19.12)
External rotation symptom side°	34.56 (21.22)
Internal rotation symptom side°	32.15 (11.69)
Hand behind back symptom side°	31.60 (14.08)

SPADI - Shoulder Pain and Disability Index; FABQ: Fear avoidance beliefs questionnaire: VAS – visual Analogue Scale

Table 3: Pearson Correlation coefficients among baseline measurements on the impaired side

	Duration	VAS	FLEX	ABD	IR	ER	SPADI F	FABQ	HBB ROM
Duration	1.00	-0.12	0.07	-0.05	0.07	-0.11	-0.05	-0.20	-0.02
VAS	-0.12	1.00	-0.02	-0.17	-0.27*	-0.09	0.19	-0.14	-0.23
FLEX	0.07	-0.02	1.00	0.48**	0.02	0.44**	-0.44**	-0.20	0.30*
ABD	-0.05	-0.17	0.48**	1.00	0.16	0.56**	-0.34**	-0.25	0.39**
IR	0.07	-0.27*	0.02	0.16	1.00	0.31	-0.03	0.01	0.21
ER	-0.11	-0.09	0.44**	0.56**	0.31	1.00	-0.26*	-0.13	0.51**
SPADI F	-0.05	0.19	-0.40**	-0.34**	-0.03	-0.26*	1.00	0.30*	-0.39**
FABQ	-0.20	-0.14	-0.20	-0.25	0.01	-0.13	0.30*	1.00	-0.14
HBB ROM	-0.02	-0.23	0.30*	0.39**	0.21	0.51**	-0.39**	-0.14	1.00

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

Duration: Symptom duration in weeks; VAS: Visual Analogue Scale pain score at maximal HBB movement (cm); FLEX: Flexion ROM˚; ABD: Abduction ROM˚; IR: Internal rotation ROM˚; ER: External rotation ROM˚; SPADI F: Shoulder Pain and

Disability Index, disability score; FABQ: Fear avoidance beliefs questionnaire score; HBB ROM: Hand behind back Range of motion°

Table 4: Unstandardized (*B*) and standardized (β) regression coefficients, T, and *p* values from multiple linear regression analysis

Dependent variable	**Independent variable**	**t**	***p***	***B***	**β**
HBB ROM	VAS Pain Score	-1.96	0.05	-2.31	-0.25
	Duration	-0.35	0.73	-0.05	-0.04
	FABQ score	-0.45	0.65	-0.08	-0.06
	SPADI function score	-2.63	0.01*	-0.46	-0.35
HBB ROM	Flexion	0.50	0.62	0.04	0.07
	Abduction	0.95	0.36	0.10	0.14
	Internal rotation	0.60	0.55	0.09	0.07
	External rotation	2.52	0.02*	0.31	0.38
SPADI score	Flexion	-2.08	0.04*	0.35	2.28
	HBB ROM	-1.68	0.10	-0.17	-0.24
	Abduction	-0.86	0.40	-0.86	0.40
	Internal rotation	-0.42	0.68	0.42	0.68
	External rotation	0.33	0.74	0.33	0.74
VAS Pain Score	Flexion	0.01	0.99	0.00	0.00

	HBB ROM	-1.66	0.10	-0.03	-0.27
	Abduction	-1.14	0.26	-0.01	-0.18
	Internal rotation	-1.78	0.08	-0.03	-0.23
	External rotation	1.30	0.20	0.02	0.25

HBB ROM: Hand behind back Range of motion˚; Duration: Symptom duration in weeks; FABQ: Fear avoidance beliefs questionnaire score; VAS: Visual Analogue Scale pain score at maximal HBB movement (cm); SPADI: Shoulder Pain and Disability Index.