Validity of an Alternate Hand Behind Back Shoulder Range of Motion Measurement in Patients With Shoulder Pain and Movement Dysfunction

Kiran H. Satpute, MPT,[a] Toby Hall, PhD,[b] and Aditi Adanani, BPT[c]

Abstract

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

Methods: This cross-sectional study design evaluated shoulder ROM, pain, fear-avoidance beliefs, and disability 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 in a manner that did not require the patient to disrobe. 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 scale for pain, Fear Avoidance Beliefs Questionnaire (FABQ), and duration of symptoms.

Results: Restriction of HBB movement was significantly correlated with SPADI total disability score ($r = 0.39$, $P < .01$), flexion ROM ($r = 0.30$, $P < .05$), abduction ROM ($r = 0.39$, $P < .01$), and external rotation ROM ($r = 0.60$, $P < .01$). 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 subscore ($P = .01$) but not by visual analogue scale score ($P = .05$), FABQ score ($P = .65$), or duration of symptoms ($P = .73$). The FABQ score was not explained by limitation in HBB ROM and shoulder movements.

Conclusion: These findings suggest that this novel method of measuring HBB ROM could be used as a functional outcome measure in the evaluation of patients with shoulder disorders. This method could be considered as an additional or alternative where there are challenges in measuring HBB because of restrictions in undressing a patient, such as for cultural reasons. (J Manipulative Physiol Ther 2018;41:242-251)

Key Indexing Terms: *Range of Motion; Shoulder; Pain; Cultural Competency*

Introduction

Musculoskeletal problems affecting the shoulder are common in Indian rural as well as urban areas, with lifetime incidence reported as 15.6%.[1-3] The 1-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 have an inability to reach overhead or 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 people with various shoulder pathologic conditions are in part determined by evaluating routinely measured cardinal plane physiological movements, as well as through functional evaluation.[8] These functional assessments commonly use 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 reported 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

[a] Department of Kinesiotherapy and Physical Diagnosis, Smt. Kashibai Navale College of Physiotherapy, Pune, Maharashatra, India.
[b] School of Physiotherapy and Curtin Health Innovation Research, Curtin University, Perth, Australia.
[c] Smt. Kashibai Navale College of Physiotherapy, Pune, Maharashatra, India.
Corresponding author: Kiran H. Satpute, MPT, 393 Navi Peth, near Vithal Mandir, Pune 411030, Maharashatra, India. Tel.: +91 9604515338. (e-mail: Kiran_ptist@yahoo.co.in).
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population.[12] Physical measures of shoulder functional impairment include hand behind neck[10] and hand behind back (HBB) measures.[13-18]

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[22] reported that improving HBB ROM improved shoulder function and pain in patients with nonspecific shoulder pain and movement impairment.

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 2 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 uses the posterior superior iliac spine as a reference point has been reported 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 using a bubble inclinometer that should be acceptable in multicultural countries because 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 purposes, measures only elbow flexion as a proxy for HBB ROM. In this measurement method, the humerus is maintained vertical by the participant's side while he or she reaches up behind the back, and elbow flexion ROM is recorded.

For goniometry to provide meaningful information, measurements must be valid and 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. In addition, Lentz et al[27] reported that pain-related fear is one of the strong predictors of shoulder disability.

The purpose of this study was to assess the criterion-related validity of a novel method of measuring HBB ROM. The primary hypothesis was that restriction of HBB ROM would correlate with shoulder-related disability and shoulder movement in other planes. The secondary hypothesis was that fear-avoidance behavior would 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 because of cultural issues associated with skin exposure.

Participants

Participants were recruited from the physiotherapy outpatient department of Smt. Kashibai Navale Medical College, Pune, India, 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 that were carried out in a typical Indian orthopedic outpatient department. These participants were evaluated by an experienced physiotherapist and were included if they were aged 18 to 70 years with a history of acute or chronic shoulder pain and associated movement restriction. Participants were excluded if they had elbow, forearm, or wrist joint pathologic conditions; 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 participants were enrolled in the study (Fig 1). Medical diagnoses are presented in Table 1. The sample size was based on 8 predictor variables in the regression analysis, with $\alpha = .05$, power of 0.8, and effect size of 0.5 requiring a sample size of at least 40.

Procedure

All participants who fulfilled the inclusion criteria and who volunteered to participate in this study were required to provide written informed consent. Demographic data for age, sex, weight, height, and baseline parameters of pain intensity during maximal HBB movement as evaluated on the 10-cm visual analogue scale (VAS),[28] disability as evaluated 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 2 subscales, pain and function.[29] The Numeric 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 intraclass correlation coefficient (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]

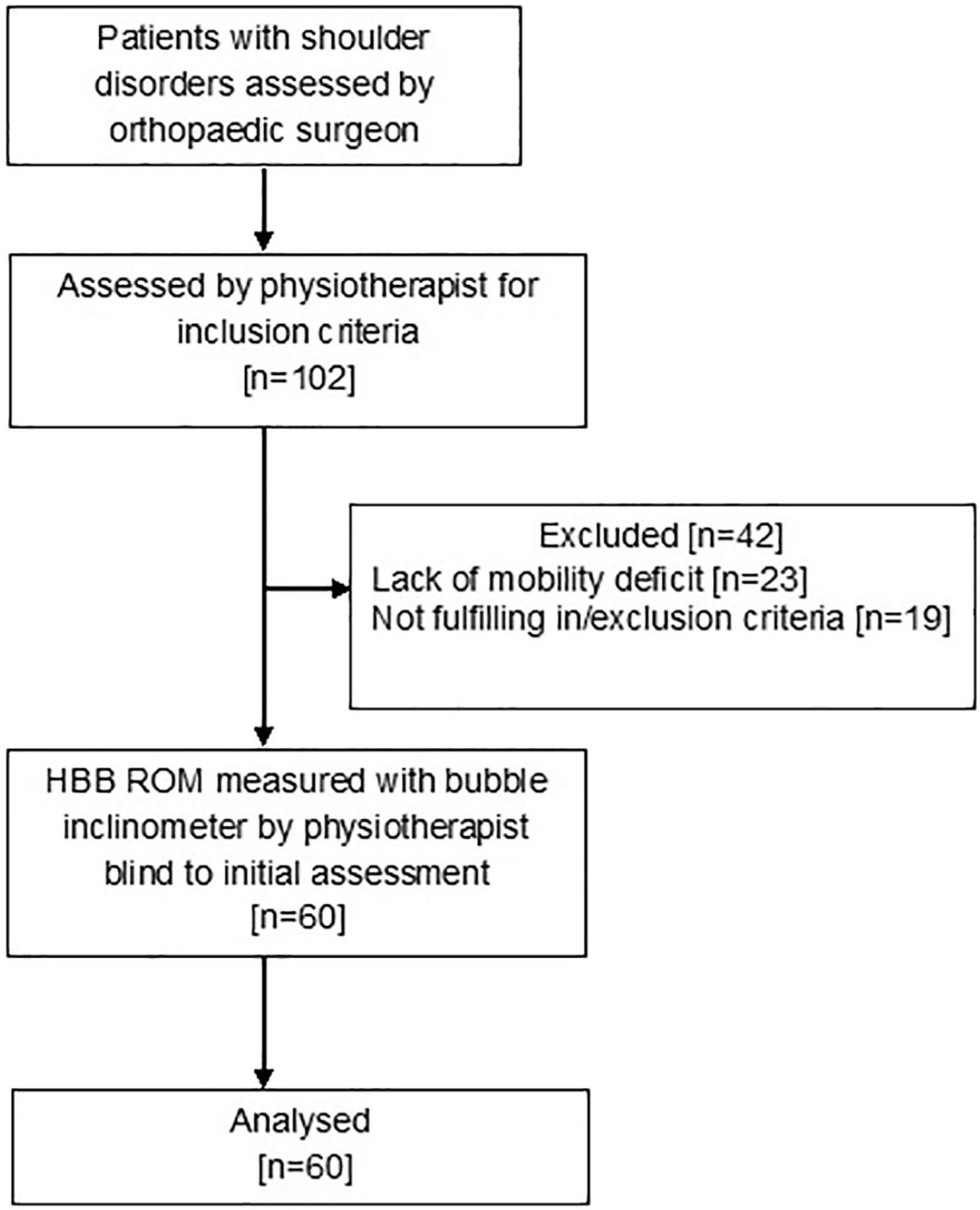

Fig 1. *The flow of participants through the study.* HBB, *hand behind back;* ROM, *range of motion.*

The FABQ was used to predict and quantify fear-avoidance behavior. The 2 subscales of FABQ contain a 4-item FABQ physical activity component with minimum score of 0 and maximum of 24; and a 7-item FABQ work component with minimum score of 0 and maximum of 42. These 2 subscales 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 low back pain.[30] The FABQ was modified to make it suitable to measure the fear-avoidance beliefs specific to shoulder and/or elbow pain. An intrarater reliability analysis for this FABQ work subscale (ICC = 0.52) and FABQ physical activity subscale (ICC = 0.59) reported low reliability.[36]

Physiological shoulder movements (Table 2) were measured using a universal goniometer with 1° increments with the participant positioned in supine. Active assisted shoulder flexion ROM with passive overpressure at the end of movement was measured by determining the angle between the midaxillary line and the lateral midline of the humerus aligning a fulcrum at the greater tuberosity.[25] Mullaney et al[37] reported the reliability of this method as excellent. Intrarater and interrater reliability ranges from 0.96 to 0.97 and 0.88 to 0.93, respectively. The MDC for shoulder ROM is at least 6°

Table 1. *Medical Diagnoses of Study Participants*

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

with a standard error of measurement 15°.[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] Intrarater reliability (ICC = 0.98) and interrater reliability (ICC = 0.87) 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° 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[40] reported good to excellent reliability for measuring internal rotation irrespective of shoulder position. The end point for all physiological movement was when pain limited the movement, with the average of 3 trials recorded.

After this, HBB ROM was measured and recorded. To reduce potential bias, the measurement of HBB ROM was carried out by the physiotherapist blind to baseline evaluation of pain, ROM, and functional measures. Hand behind back ROM was measured on the affected side using a bubble inclinometer (Baseline, Lyons, Colorado) placed on the lateral aspect of radius proximal to the radial styloid process (Fig 2). This device consisted of a fluid-filled chamber covered with movable 360° scale divided into 1° increments. The procedure was explained and a demonstration was given to familiarize the participant with the required movement. While standing, the participant was instructed to actively move the HBB as far as possible, keeping the dorsum of the hand in contact with the back and avoiding compensatory scapular elevation or spine movement. Once the hand reached the sacrum, participants were asked to trace their thumb up their spine along the line of the spinous processes. Incorrect movement was corrected by the examiner using verbal and tactile clues before final measurements were taken. Once the end position was reached, 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 (0°) with the arm by the side, elbow in full extension, forearm pronation, and maximum possible HBB position was measured in degrees using the bubble inclinometer (Fig 1).

Table 2. *Descriptive Statistics and Mean Range of Motion, Pain, and Disability Measures of Study Participants*

Characteristics	Mean (SD)
Age, y	55.70 (8.73)
Weight, kg	61.78 (13.10)
Height, cm	158.81 (14.79)
Symptom duration, wk	15.73 (11.20)
Pain with maximum HBB movement, VAS score	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)
HBB symptom side (°)	31.60 (14.08)

FABQ, Fear Avoidance Beliefs Questionnaire; *HBB,* hand behind back; *SD,* standard deviation; *SPADI,* Shoulder Pain and Disability Index; *VAS,* visual analogue scale.

An average of 3 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. Intrarater reliability (ICC = 0.97, 95% CI 0.95-0.99) and interrater reliability (ICC = 0.96, 95% CI 0.91-0.98) values indicate excellent reliability, with a standard error of measurement and MDC of 2° and 6°, respectively.[41]

The assessment was completed without preparatory warmup 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 Smt. Kashibai Navale College of Physiotherapy, Pune, India.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS Version 19, IBM Corp, Armonk, New York) software was used for statistical analysis. Descriptive statistics were calculated for demographic, ROM impairment, pain with maximum HBB

Fig 2. *Demonstration of inclinometer placement.*

movement, and self-report questionnaire data. Correlations were calculated between each ROM impairment measure, demographic variable, FABQ score, and SPADI function subscore 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 subscore. Before analyses, all assumptions for the use of multiple linear regression analysis were assessed.

Results

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

Correlation coefficients among variable are listed in Table 3. Hand behind back ROM on the impaired side had a significant univariate correlation with SPADI total disability score (0.39, $P < .01$), flexion ROM (r = 0.30, $P < .05$), abduction ROM (0.39, $P < .01$), and external rotation ROM (r = 0.51, $P < .01$). Other variables were not significantly correlated.

Before interpreting the results of the multiple linear regression analysis, several assumptions were evaluated and determined 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 *P* are 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 subscore, and duration of symptoms. This was significant ($F_{[4,\ 53]}$ = 3.36, $P = .02$) with examination of *t* values indicating that only SPADI disability subscore ($t = –2.63$, $P = .01$) contributed to the prediction of HBB ROM. In contrast to the SPADI score, the VAS pain score was not significant ($t = –1.96$, $P = .05$).

Table 3. *Pearson Correlation Coefficients Among Baseline Measurements on the Impaired Side*

Variable	Duration	VAS	FLEX	ABD	IR	ER	SPADI F	FABQ	HBB ROM
Duration [a]	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 [b]	–0.09	0.19	–0.14	–0.23
FLEX	0.07	–0.02	1.00	0.48 [c]	0.02	0.44 [c]	–0.44 [c]	–0.20	0.30 [b]
ABD	–0.05	–0.17	0.48 [c]	1.00	0.16	0.56 [c]	–0.34 [c]	–0.25	0.39 [c]
IR	0.07	–0.27 [b]	0.02	0.16	1.00	0.31	–0.03	0.01	0.21
ER	–0.11	–0.09	0.44 [c]	0.56 [c]	0.31	1.00	–0.26 [b]	–0.13	0.51 [c]
SPADI F	–0.05	0.19	–0.40 [c]	–0.34 [c]	–0.03	–0.26 [b]	1.00	0.30 [b]	–0.39 [c]
FABQ	–0.20	–0.14	–0.20	–0.25	0.01	–0.13	0.30 [b]	1.00	–0.14
HBB ROM	–0.02	–0.23	0.30 [b]	0.39 [c]	0.21	0.51 [c]	–0.39 [c]	–0.14	1.00

ABD, abduction; *ER,* external rotation; *FABQ,* Fear Avoidance Beliefs Questionnaire; *FLEX,* flexion; *HBB,* hand behind back; *IR,* internal rotation; *ROM,* range of motion; *SPADI F,* Shoulder Pain and Disability Index disability subscale score; *VAS,* visual analogue scale pain score at maximal HBB movement (cm).

[a] Symptom duration in weeks.

[b] Correlation is significant at the .05 level.

[c] Correlation is significant at the .01 level.

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	.05	–2.31	–0.25
	Duration [a]	–0.35	.73	–0.05	–0.04
	FABQ score	–0.45	.65	–0.08	–0.06
	SPADI function score	–2.63	.01 [b]	–0.46	–0.35
HBB ROM	Flexion	0.50	.62	0.04	0.07
	Abduction	0.95	.36	0.10	0.14
	Internal rotation	0.60	.55	0.09	0.07
	External rotation	2.52	.02 [b]	0.31	0.38
SPADI score	Flexion	–2.08	.04 [b]	0.35	2.28
	HBB ROM	–1.68	.10	–0.17	–0.24
	Abduction	–0.86	.40	–0.86	0.40
	Internal rotation	–0.42	.68	0.42	0.68
	External rotation	0.33	.74	0.33	0.74
VAS pain score	Flexion	0.01	.99	0.00	0.00
	HBB ROM	–1.66	.10	–0.03	–0.27
	Abduction	–1.14	.26	–0.01	–0.18
	Internal rotation	–1.78	.08	–0.03	–0.23
	External rotation	1.30	.20	0.02	0.25

FABQ, Fear Avoidance Beliefs Questionnaire; *HBB,* hand behind back; *ROM*, range of motion; *SPADI,* Shoulder Pain and Disability Index; *VAS,* visual analogue scale pain score at maximal HBB movement (cm).

[a] Symptom duration in weeks.

[b] Significant $P < .05$.

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 ($F_{[4, 55]} = 5.36$, $P < .01$), with examination of t values indicating that only external rotation ROM (t = 2.52, P = .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 ($F_{[5, 53]} = 1.81$, $P = .13$) 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 = .01), with examination of t values indicating that only flexion ROM ($t = –2.08$, $P = .04$) 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 subscore and external rotation ROM. Likewise shoulder disability identified by the SPADI function subscore was only partly explained by an index of shoulder flexion ROM.

Discussion

The results of this study indicated 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 subscore, 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 because 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 subscore, and duration of symptoms. The secondary hypothesis regarding correlation between fear-avoidance behavior and shoulder movement impairment was rejected.

An important finding from our study was the association between HBB ROM and disability measured by the SPADI function subscore but not with the pain subscore. We did not incorporate the SPADI pain subscore in the analysis because 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 ($P = .05$). The SPADI disability subscale has 2 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[42] also reported a significant correlation between HBB ROM and pain subscale ($P = .01$) and function subscale ($P < .001$) 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 ROM restriction typically occurs 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 noncapsular patterns of movement restriction[43] and is thus a common occurrence in patients referred for physiotherapy for shoulder pain. This was true for our sample of patients referred through a typical orthopedic 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[23] reported that in normal participants, there is a mean range of 48.4° shoulder internal rotation, which occurs when the hand reaches the sacrum during the movement of HBB. 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 used 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 thereafter by scapulothoracic movement.[20] Hence, this point may explain the lack of correlation we identified between internal rotation and HBB ROM. Future studies using radiologic analysis are recommended to further evaluate HBB ROM as determined by the new method of measurement for greater understanding of this complex movement.

The present study is the first to correlate loss of HBB ROM with other commonly assessed shoulder movements in patients with shoulder pain and movement restriction. Wakabayashi et al[23] reported that shoulder abduction increased significantly in the initial phase of the normal movement of HBB until the hand reaches the buttock position. 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 identified between HBB ROM and external rotation ROM could be attributed to the participants included in our study. The most common diagnosis was adhesive capsulitis; moreover, the mean duration of symptoms was 15.7 weeks, highlighting the chronic nature of the conditions of the participants. External rotation restriction is a common movement limitation 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 highlighted in a recent study undertaken by our group. Patients with shoulder pain and nonspecific 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, after which there was significant and clinically important improvement in HBB ROM, pain intensity, and disability scores as measured with SPADI, with a mean difference of 16.20 cm (3.99 cm), 5.31 cm (1.80 cm), and 40.63 cm (6.47 cm), 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 is presented in Table 3. These findings indicate 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,[33] who reported on the construct validity of the SPADI in people with shoulder disorders, with exception of external rotation movement. These findings suggest shoulder flexion, abduction, and external rotation ROM impairment also need 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[48] reported no correlation between shoulder ROM restriction and pain, which supports our findings of a lack of correlation between HBB ROM and pain (P = .05).

In contrast to other forms of musculoskeletal dysfunction such as low back and neck pain, there was a low correlation between SPADI disability subscale and fear-avoidance behavior as measured by the FABQ (r = 0.30). In addition, fear-avoidance behavior was explained neither 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[49] previously reported that biopsychosocial factors do influence shoulder pain. The possible explanation for these 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 participants 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 because its validity and reliability have not been determined for the upper extremities.

Conclusion

This 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 could be considered as an additional or alternative where there are challenges in measuring HBB because of restrictions in undressing.

Funding Sources and Conflicts of Interest

No funding sources or conflicts of interest were reported for this study.

Contributorship Information

Concept development (provided idea for the research): K.H.S.
Design (planned the methods to generate the results): K.H.S., T.H., A.A.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): T.H.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): K.H.S., A.A.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): K.H.S., T.H.
Literature search (performed the literature search): K.H.S., A.A.
Writing (responsible for writing a substantive part of the manuscript): K.H.S., T.H.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): T.H.

Practical Applications

- This study presents a novel method for measuring HBB ROM without requiring skin exposure.
- This study determined that this is a valid method to evaluate patients with shoulder disorders.

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