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## ORTHOPEDICS | RESEARCH ARTICLE

# Pain, functional disability, psychological status, and health-related quality of life in patients with subacromial impingement syndrome

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**Abstract:** *Background:* Subacromial Impingement Syndrome (SAIS) is the commonest painful shoulder condition leading to considerable functional loss. Considering numerous existing conservative and surgical interventions for SAIS, the use of optimal patient-centred outcome measures is essential. Study assessed various generic and shoulder-specific outcome measures in patients and healthy controls to provide baseline data and facilitate the development of evidence-based interventions. *Methods:* A total of 75 participants including 39 patients and 36 healthy controls were evaluated and compared by a battery of validated outcome tools: McGill Pain Questionnaire, Oxford Shoulder Score, Constant Murley Score, The Disability of the Arm, Shoulder and Hand, Upper Limb Function Index, Functional Impairment Test-Hand and Neck/Shoulder/Arm, Hospital Anxiety and Depression Scale, Short-Form Health Survey, and shoulder muscle strength. *Results:* All selected measures showed significant differences in the pain experience, upper limb functional capacity, psychological status (anxiety and depression), and health-related quality of life between SAIS patients and healthy controls in both female and male participant groups ( $p < 0.05$ – $p < 0.001$ ). *Conclusion:* The use of an array of patient-centred upper limb regional/joint-specific pain and functional measures combined

### ABOUT THE AUTHORS

For more than a decade, the team's clinical research has focused on upper extremity, shoulder in particular, by means of investigating the normal function, underlying mechanism of common pathologies, outcome of surgical procedures, and evidence-based prescription of rehabilitation exercises. The majority of our current research projects apply a multidimensional approach by integrating a blend of interlinked assessments, predominantly EMG, 3D motion capture, dynamometry, functional tasks, and validated outcome tools. The present study reporting on the use of different outcome measure tools for the subacromial impingement syndrome is a part of larger and more comprehensive project, which investigated the multifactorial aetiology of this condition. The findings, however, can be generalized to other common painful conditions of the shoulder especially those affecting the rotator cuff complex.

### PUBLIC INTEREST STATEMENT

Subacromial impingement syndrome is the commonest diagnosis in patients visiting their physicians due to chronic shoulder pain (44–65%). This painful condition can lead to substantial limited range of movement and functional loss during daily activities. Several modalities such as physical and exercise therapy, shock-wave therapy, corticosteroid injection, medication, and surgery are available for the management of this condition. Hence, it is important to identify the most appropriate outcome measures for evaluating the efficiency of these interventions. This study assessed and compared the use of several outcome measures in patients and healthy controls in order to facilitate the development of evidence-based interventions. Study findings supported the use of a combination of shoulder-specific, pain, and functional measures together with psychological and quality of life outcome assessment tools in patients suffering from subacromial impingement syndrome.

with psychological status and quality of life tools is recommended for the evidence-based assessment of intervention outcome in patients with SAIS.

**Subjects: Orthopedics; Primary Health Care & Family Practice; Rehabilitation Medicine; Physiotherapy**

**Keywords: subacromial impingement syndrome; upper limb function; outcome assessment; quality of life; psychological status**

### 1. Background

Subacromial Impingement Syndrome (SAIS) is the most common diagnosis in patients visiting the physicians with chronic shoulder pain (44–65%) with a cumulative incidence of 5 per 1,000 patients a year (Umer, Qadir, & Azam, 2012). The insidious anterior or anterolateral superior pain particularly during arm elevation within the painful arc (70 and 120° of abduction) and overhead movements (essential for daily and work/sport activities) gradually leads to the functional loss and disability. While SAIS has been linked to the mechanical compression of rotator cuff and subacromial tissues between the proximal end of the humerus and coracoacromial arch the exact aetiopathology remains unclear (Neer, 2005). Neer (2005) argued that the anterior one-third of the acromion, the coracoacromial ligament and, at times, the acromioclavicular joint impinge upon subacromial components during forward arm elevation. Recent electromyographic (EMG) studies have provided some evidence on the role of muscle activation imbalances in the development of SAIS by means of over-activation of upper trapezius and under-activation of middle- and lower trapezius and serratus anterior (Struyf et al., 2014).

The current evidence falls short in identifying optimal conservative and surgical interventions for the SAIS (Aydin et al., 2014). While nonsteroidal anti-inflammatory medications, activity modifications, and subacromial corticosteroid injections considered the commonest conservative modalities, there is growing evidence on the efficacy of individualised rehabilitation exercises aiming to correct muscular imbalances and improve posture misalignments (Page, 2011). According to a recent review of 616 patients, 67% responded satisfactorily to conservative rehabilitation interventions with 18% showing recurrence of symptoms and 28% requiring arthroscopic subacromial decompression (Morrison, Frogameni, & Woodworth, 1997). Randomised controlled trials have reported that strengthening strategies implementing eccentric rotator cuff exercises and concentric/eccentric scapular exercises may lead to significant pain and functional improvements in SAIS (Holmgren, Bjornsson Hallgren, Oberg, Adolfsson, & Johansson, 2012).

Considering pain relief and enhancements in functional performance and health-related quality of life as the most important indicators of any intervention, the importance of applying appropriate patient-centred questionnaires and outcome assessment tools in SAIS is evident. However, considering the high prevalence of SAIS, uncertainties regarding its optimal management, and substantial socioeconomic burden, it would be highly feasible to utilise multidimensional tools in order to enhance management strategies by a better understanding of pain experience, functional disability, and health-related quality of life particularly from patients' perspective. Recent reviews of shoulder outcome tools reported the highest ratings for the Disability of the Arm, Shoulder and Hand (DASH) and Oxford Shoulder Score (OSS) in terms of responsiveness, clinical application, and clinometric properties (Angst, Schwyzer, Aeschlimann, Simmen, & Goldhahn, 2011). Additional tools such as McGill pain questionnaire (MPQ) and Short Form Health Survey (SF-12) may further assess patient's pain experience and health-related quality of life. The consideration of psychological factors has been increasingly suggested for a complete understanding of clinical outcomes due to a strong relationship between mental well-being and physical health. Previous authors have reported an association between chronic musculoskeletal pain and depression and anxiety and highlighted the importance of screening patients for elevated levels of anxiety and depression by clinicians involved in musculoskeletal rehabilitation programmes (Parker & Wright, 1997; Stevens, Merikangas, & Merikangas, 1995). It is also suggested that the assessment and identification of patients with high

levels of anxiety and depression should be given high priority considering their subsequent impact on pain experience and quality of life (Harter, Reuter, Gross-Hardt, & Bengel, 2001). Hence, to address the association of psychologic factors and SAIS in musculoskeletal settings, the use of validated tools such as the Hospital Anxiety and Depression Scale (HADS) is highly applicable (Cho, Song, Hwang, & Warner, 2015).

In addition to questionnaires, simple patient-centred functional assessment tools such as the Functional Impairment Test-Hand and Neck/Shoulder/Arm (FIT-HaNSA) (integrated assessment of shoulder strength, stability, mobility, coordination, ROM) have shown to produce reliable data on the functional performance of patients with rotator cuff pathologies (MacDermid et al., 2007; MacDermid, Ramos, Drosdowech, Faber, & Patterson, 2004). The use of isometric strength assessment methods are suggested for the identification of muscle dysfunction and weakness associated with prolonged SAIS which occurs as a result of muscular imbalance initially originating from scapular muscles and then affecting key glenohumeral muscles (Ellenbecker & Cools, 2010).

While several conservative management modalities such as physical and exercise therapy, shock-wave therapy, corticosteroid injection, medication, and surgery are available for the SAIS, the effectiveness of such interventions can only be systematically assessed and supported using a feasible combination of multidimensional outcome measures. The majority of previous research focused on patients' physical functioning using a limited number of patient-centred measures. Hence, the principal aims of this study were to provide baseline data and a comparative analysis of pain experience, functional capacity, psychologic status, and quality of life between patients with SAIS and healthy controls using a broad range of well-recognised outcome measures.

## 2. Methods

### 2.1. Participants

A total of 75 controls and patients with SAIS participated in the study: (1) Control Group included 36 healthy volunteers with normal upper limb clinical assessment and no history of upper extremity painful conditions or surgery (15 females-42.9 ± 9.3 years old; 21 males-47.6 ± 10.3 years old); (2) Patient group comprised of 39 participants (20 females-55.5 ± 5.3 years old; 19 males-54.2 ± 8.1 years old) diagnosed by the same clinician from a single Upper Limb Unit. All patients presented with persistent shoulder pain for at least 12 weeks and a range of positive clinical tests (Painful arc, Neer's, Hawkin's, Lift Off, Empty Can) for the SAIS (Diercks et al., 2014). Patients with a coexisting musculoskeletal disorder affecting the upper limb, treatment other than for pain relief during the last three months, positive imaging (rotator cuff tear, instability, osteoarthritis), and systemic diseases affecting the function of neck, back and upper extremity were excluded. The study received Local Research Ethics Committee approval and all participants gave their written informed consent.

### 2.2. Assessment procedures

#### 2.2.1. Pain, upper extremity function, psychological status, and quality of life

Generic and joint-specific upper extremity tools were used to register pain, functional impairment, alteration in daily activities, psychological status, and quality of life:

- *McGill Pain Questionnaire (MPQ)* is a widely used tool in both clinical and research settings for assessing characteristics of pain (Melzack, 1975). The reliability and validity of MPQ are well-documented (Katz & Melzack, 2011; Melzack, 1975). While MPQ measures four different subscales (Continuous, Intermittent, Neuropathic, and Affective), the total score is commonly used to specify subjective pain experience.
- *Constant Murley Score (CS)* is the gold standard shoulder scoring systems in Europe designed for subjective and clinical evaluation of pain, daily activities, range of motion, and strength (Razmjou

et al., 2008). A high test-retest reliability of  $r = 0.80$ – $0.96$  has been reported for the CS (Roy, MacDermid, & Woodhouse, 2010).

- *Oxford Shoulder Score (OSS)* is a validated joint specific scoring system specifically designed for the self-assessment of pain and function in patients suffering from shoulder pathology other than instability (Dawson, Hill, Fitzpatrick, & Carr, 2001). The OSS has a high internal reliability/consistency (Cronbach’s  $\alpha = 0.94$ ) and test-retest reliability ( $r = 0.98$ ) (Huber, Hofstaetter, Hanslik-Schnabel, Posch, & Wurnig, 2004).
- *The Disability of the Arm, Shoulder and Hand (DASH)* is a patient-reported tool to assess upper extremity-related symptoms and functional disability by means of pain, weakness, stiffness and tingling/numbness; daily/recreational activities, social interaction and psychological function (Hudak, Amadio, & Bombardier, 1996). It has a high internal reliability (Cronbach’s  $\alpha = 0.92$ – $0.98$ ) and test-retest reliability ( $r = 0.93$ – $0.98$ ) (Beaton et al., 2001; Kennedy, Beaton, Solway, McConnell, & Bombardier, 2011).
- *Upper Limb Function Index (ULFI)* is a reliable ( $r = 0.94$ ) patient-reported outcome measure for evaluating the status of functional loss pertained specifically to musculoskeletal upper extremity disorders and related impact on patient’s health (Chesworth et al., 2014; Gabel, Michener, Burkett, & Neller, 2006).
- *Hospital Anxiety and Depression Scale (HADS)* is an efficient reliable instrument in assessing the symptom severity and caseness of anxiety (AC) and depression (DC) in musculoskeletal, psychiatric and primary care patients. Its validity and bi-dimensionality was supported in a systematic review paper published by Bjelland, Dahl, Haug, and Neckelmann (2002) and a high reliability has been reported for both anxiety ( $r = 0.83$ ) and depression ( $r = 0.84$ ) subscales using Cronbach alpha value (Pallant & Bailey, 2005).
- *Short Form General Health Survey (SF-12)* is commonly used to quantify the impact of health on two components of physical (PC) and mental (MC) (Ware, Kosinski, & Keller, 1996). SF-12 has a high internal consistency (Cronbach’s  $\alpha \geq 0.82$  and  $0.75$ , for SF-12 PCS scale and MCS scale, respectively) (Luo et al., 2003) and test-retest reliability ( $r = 0.89$  for PCS and  $r = 0.76$  for MCS) (Resnick & Nahm, 2001).

### 2.2.2. Functional impairment test-hand and neck/shoulder/arm (FIT-HaNSA)

The FIT-HaNSA has been used for assessing upper extremity functional status (motion, strength, and muscular endurance essential for completing a particular task) in patients with a spectrum of shoulder pathologies including SAIS (MacDermid et al., 2007; Kumta, MacDermid, Mehta, & Stratford, 2012). The test simulates daily activities of forward reaching at different levels in forms of three tasks (Table 1). Subjects were instructed to perform each task either for 5 min or until a stopping criterion is met (MacDermid et al., 2007). Each task was scored as the percentage of completion (100% representing the best function) with the mean score of 3 individual tasks taken as total score.

**Table 1. Summary of the FIT-HaNSA\* testing protocol**

Tasks	Lower shelf position	Higher shelf position	Action	Guide	Duration
Task1: Waist up	Waist level	25 cm above the lower shelf	Lifting 3 weights from lower to higher shelf and return	Metronome set at 60 beats/min—Coloured spots on shelves	5 min
Rest					30 sec
Task 2: Eye-down	25 cm below the higher shelf	Eye-level	Lifting 3 weights from lower to higher shelf and return	Metronome set at 60 beats/min—Coloured spots on shelves	5 min
Rest					30 sec
Task 3: Over-head	No	Eye-level with perpendicular plate	Moving two bolts between three holes in rotation	Holes in the perpendicular plate	5 min

Note: FIT-HaNSA\* = The functional impairment test-head, and neck/shoulder/arm.

### 2.2.3. Shoulder muscle strength

A Mecmesin Shoulder Myometer (Mecmesin Ltd. Slinfold, UK) was used to measure the strength of shoulder muscle groups. Participants were seated in upright position with both hips and knees flexed to 90° and feet apart and flat on the ground. Strength was measured during four standard movements on a random order: (1) *forward elevation* with the shoulder at 90° flexion, elbow in extension and the forearm in pronation, (2) *scapular plane elevation* with the shoulder at 90° of abduction, elbow in extension and the hand in “full can” position, (3) and (4) *external and internal rotation* with the shoulder in neutral position, the elbow in 90° flexion tucked to the side of the body and the forearm in neutral position. With the strap of myometer was placed at the wrist level, each measurement was repeated three times with 60 s rest in-between the tests and average taken for analysis.

### 2.3. Data analysis and statistics

Descriptive statistics for pain (MPQ), upper extremity functional scores (OSS, CS, DASH, ULFI), psychological status (HADS), quality of life self (SF-12), and functional objective tests (FIT-HaNSA, Muscle Strength, ROM) are reported separately for female and male groups of patient and controls as mean ± standard deviation (SD). The originally established scoring formula was applied for calculating the subscale and total scores of each questionnaire/functional score as appropriate. The Shapiro-Wilk test was used to analyse normal distribution assumption of the quantitative outcomes. For the data not normally distributed the non-parametric Mann-Whitney U test and for the data with normal distribution the independent-sample *t*-test were used to determine significant between-group differences. The level of significance was set at  $p < 0.05$ . The SPSS statistical package (Version 20.0; IBM, Armonk, NY, USA) was used for analysis and modeling of the data.

## 3. Results

### 3.1. Questionnaires and outcome scores

No difference in the demographics was observed between controls and patients for either gender. Tables 2 and 3 present and compare different measurements for the female and male patients and healthy controls, respectively.

#### 3.1.1. Female participants

All measures used for pain, function, psychological status, and quality of life revealed significant differences between the affected shoulder of female patients and healthy controls ( $p < 0.001$ ). The SF-12 was approximately 50% less in SAIS patients in contrast to healthy controls for both physical and mental subscales underpinning a marked reduction in patients' health-related quality of life.

#### 3.1.2. Male participants

The scores of all other upper extremity tools including CMS, OSS, DASH, and ULFI were significantly lower for the patient group compared to the controls ( $p < 0.001$ ). Furthermore, the results of MPQ and SF-12 indicated a significantly higher pain experience and lower quality of life in patients ( $p < 0.001$ ).

### 3.2. Functional assessments (FIT-HaNSA, Muscle Strength, ROM)

#### 3.2.1. Female participants

The scores for individual FIT-HaNSA tasks and the total score were significantly lower in patients compared to the control group (43.9 vs. 96.6%;  $p < 0.001$ ). The strength measurements revealed markedly lower strength in all muscle groups ( $p < 0.001$ ) in patients with the highest deficit (~50%) observed in relation to flexors, abductors and internal rotators. ROM in patients was significantly lower for all measured shoulder movements compared to the controls.

#### 3.2.2. Male participants

Patients had significantly reduced scores for individual tasks and the total FIT-HaNSA scores compared to the controls (59.9 vs. 98.5%;  $p < 0.001$ ). Muscle strength was also markedly lower in

**Table 2. Comparisons of functional measurements and patient-centred outcome scores between female SAIS patients and healthy controls**

Measurement	SAIS patients	Controls	p
<i>MVC (N)</i>			
Flexors	37.7 ± 15.8	67.8 ± 9.9	<0.001**
Abductors	31.4 ± 13.2	64.1 ± 9.1	<0.001**
External rotators	52.1 ± 13.7	77.8 ± 15.3	<0.001**
Internal rotators	66.0 ± 30.6	124.4 ± 33.4	<0.001**
<i>ROM (°)</i>			
Flexion	127 ± 30	180.0 ± 0.0	<0.001**
Extension	35 ± 8.7	53.8 ± 5.0	<0.001**
Abduction	111 ± 31	180.0 ± 0.0	<0.001**
Horiz. adduction	39 ± 10	45.4 ± 3.7	0.02*
External rotation	53 ± 17	86.5 ± 4.9	<0.001**
<i>FIT-HaNSA</i>			
WUT (%)	58.4 ± 24.1	100.0 ± 0.0	<0.001**
EDT (%)	29.8 ± 15.8	92.1 ± 11.8	<0.001**
OHT (%)	43.6 ± 17.7	97.7 ± 4.7	<0.001**
AVERAGE	43.9 ± 17.3	96.6 ± 4.9	<0.001**
CMS (0-100)	49.2 ± 14.1	88.8 ± 1.8	<0.001**
Pain (0-15)	7.0 ± 3.3	15.0 ± 0.0	<0.001**
Activity (0-20)	11.1 ± 3.5	20.0 ± 0.0	<0.001**
ROM (0-40)	23.9 ± 7.5	39.8 ± 0.7	<0.001**
Power (0-25)	7.0 ± 3.0	14.4 ± 2.1	<0.001**
OSS (0-48)	23.7 ± 8.2	48.0 ± 0.0	<0.001**
DASH (0-100)	53.8 ± 14.2	0.4 ± 1.2	<0.001**
DASH Op1 (0-100)	22.7 ± 26.8	0.0 ± 0.0	<0.01*
DASH Op2 (0-100)	19.1 ± 32.4	0.0 ± 0.0	0.05
ULFI (0-100)	46.8 ± 17.3	0.0 ± 0.0	<0.001**
MPQ (0-78)	22.7 ± 12.3	0.0 ± 0.0	<0.001**
HADS (0-42)	14.9 ± 8.5	1.2 ± 2.1	<0.001**
HADS_AC (0-21)	8.8 ± 4.4	0.8 ± 1.4	<0.001**
HADS_DC (0-21)	6.2 ± 4.5	0.4 ± 1.0	<0.001**
SF12 (12-56)	33.6 ± 7.4	16.2 ± 2.0	<0.001**
SF12_PC (6-28)	16.6 ± 3.9	8.7 ± 1.7	<0.001**
SF12_MC (6-28)	17.1 ± 4.0	7.5 ± 0.7	<0.001**

Notes: MVC = Maximum Voluntary Contraction; ROM = Range of Motion; FIT-HaNSA = Functional Impairment Test-Hand and Neck/Shoulder/Arm (WUT = Waist-Up Task; EDT: Eye-Down Task; OHT: Overhead Task); CMS = Constant-Murley Score; OSS = Oxford Shoulder Score; DASH = Disability of arm, shoulder and Hand (Op1 = option 1; Op2 = option 2); ULFI = Upper Limb Functional Index; MPQ = McGill pain questionnaire; HADS = Hospital Anxiety and Depression Scale (AC = Anxiety Component; DC = Depression Component); SF-12 = Short Form Health Survey (PC = Physical Component; MC = Mental Component)

\*p < 0.05.

\*\*p < 0.001.

patients for all muscle groups ( $p < 0.001$ ) with the highest deficit (~30%) observed for internal rotators. ROM was significantly lower for all shoulder movements in affected shoulders compared to controls ( $p < 0.05$ – $p < 0.001$ ).

**Table 3. Comparisons of functional measurements and patient-centred outcome scores between male SAIS patients and healthy controls**

Measurement	SAIS patients	Controls	<i>p</i>
<i>MVC (N)</i>			
Flexors	71.3 ± 36.2	103.7 ± 18	<0.001*
Abductors	58.9 ± 34.6	94.5 ± 14.6	<0.001*
External rotators	84.9 ± 38	110.4 ± 27.7	<0.001*
Internal rotators	122.6 ± 71.1	175.8 ± 55.4	<0.001*
<i>ROM (°)</i>			
Flexion	138 ± 41.7	178 ± 4	<0.001*
Extension	39 ± 8.9	51 ± 58	<0.001*
Abduction	130 ± 45.8	178 ± 4	<0.001*
Horiz. adduction	38 ± 8.9	42 ± 3	0.02*
External rotation	53 ± 16.4	75 ± 9	<0.001*
<i>FIT-HaNSA</i>			
WUT (%)	51.9 ± 29.2	100 ± 0	<0.001*
EDT (%)	60 ± 25.8	96.8 ± 7.1	<0.001*
OHT (%)	59.9 ± 26	99.2 ± 2.7	<0.001*
AVERAGE	69.8 ± 32.1	98.5 ± 3.2	<0.001*
CMS (0-100)	54.0 ± 23.9	14.4 ± 1.6	<0.001**
Pain (0-15)	6.6 ± 4.2	19.6 ± 1.2	<0.001**
Activity (0-20)	10.3 ± 5.5	39.5 ± 2	<0.001**
ROM (0-40)	23.5 ± 10.5	21.1 ± 2.8	<0.001**
Power (0-25)	14.2 ± 7.6	94.8 ± 4.3	<0.001**
OSS (0-48)	24.2 ± 8.1	46.4 ± 2.6	<0.001**
DASH (0-100)	50.5 ± 17.4	1.9 ± 3.5	<0.001**
DASH Op1 (0-100)	39.6 ± 32.3	0.6 ± 1.9	<0.001**
DASH Op2 (0-100)	34.0 ± 36.2	1.2 ± 5.5	<0.001**
ULFI (0-100)	51.1 ± 17.5	2.9 ± 7.1	<0.001**
MPQ (0-78)	28.0 ± 18.7	1.7 ± 3.9	<0.001**
HADS (0-42)	16.2 ± 10.8	0.3 ± 0.7	<0.001**
HADS_AC (0-21)	9.2 ± 5.8	0.3 ± 0.7	<0.001**
HADS_DC (0-21)	6.3 ± 6.0	0.0 ± 0.0	<0.001**
SF12 (12-56)	33.3 ± 10.2	17.4 ± 3.4	<0.001**
SF12_PC (6-28)	16.5 ± 4.6	9.0 ± 2.1	<0.001**
SF12_MC (6-28)	18.1 ± 4.9	8.4 ± 1.7	<0.001**

Notes: MVC = Maximum Voluntary Contraction; ROM = Range of Motion; FIT-HaNSA = Functional Impairment Test-Hand and Neck/Shoulder/Arm (WUT = Waist-Up Task; EDT = Eye-Down Task; OHT = Overhead Task); CMS = Constant-Murley Score; OSS = Oxford Shoulder Score; DASH = Disability of arm, shoulder and Hand (Op1 = option 1; Op2 = option 2); ULFI = Upper Limb Functional Index; MPQ = McGill pain questionnaire; HADS = Hospital Anxiety and Depression Scale (AC = Anxiety Component; DC = Depression Component); SF-12 = Short Form Health Survey (PC = Physical Component; MC = Mental Component).

\**p* < 0.05.

\*\**p* < 0.001.

#### 4. Discussion

The integration of objective and subjective assessments into clinical studies of painful and debilitating musculoskeletal conditions has increasingly become important in order to support the development of tailored evidence-based treatment strategies and facilitate follow-up outcome assessments. Recent systematic reviews have highlighted the advantage of using wide-ranging generic and condition-specific measures that conceptualize assessments of shoulder function and pain from a biopsychosocial perspective (Roe, Soberg, Bautz-Holter, & Ostensjo, 2013). The present study applied a combination of measures to determine the impact of shoulder problem on the upper limb function (FIT-HaNSA, muscle strength, CMS, OSS, DASH and ULFI), characteristics and intensity of pain (MPQ), psychosocial implications (HADS), and the impact on health-related quality of life (SF-12) in patients with SAIS. All measures were able to distinguish a significant difference between patients and healthy controls. Furthermore, while several clinical studies have produced normative values for common upper extremity functional tools in healthy populations and in SAIS patients before and after intervention; there are no distinctive gender-specific reports. While pre- and post-intervention scores obtained from the SAIS patients can help with outcome assessment, it is imperative that normative data are also available to facilitate a more insightful understanding of clinical outcome and applied interpretation. Finally, the data provide a base for comparison and interpretation of data across interventional studies involving SAIS patients.

##### 4.1. Patient-centred questionnaires and outcome scores

The usefulness of OSS as a condition-specific patient-based measure for long term follow-up in SAIS patients has been highlighted particularly in relation to its high response rate and correlation with the clinical assessments (Dawson, Hill, Fitzpatrick, & Carr, 2002). The OSS results showed a significant reduction (50–55%) in total mean score for both female and male patients underpinning a substantial functional deficit. Cloke et al. (2005) compared the OSS for correlation, agreement, sensitivity to change, test-retest reliability, and correlation with the SF-36 in 110 female and male SAIS patients and recommend it as outcome assessment tool of choice in SAIS due to high test-retest reliability, good effect size across patients, and reflecting significant clinical changes in patients receiving different treatments. Recent studies have established its Smallest Detectable Change (SDC: 6.0 points on a scale from 12 to 60) and Minimal Important Change (MIC: 6.0 and 4.7 corresponding to the functional and pain anchors, respectively) as the two important benchmarks for interpreting score changes (Christiansen et al., 2015). The increasing OSS data from outcome studies, particularly in relation to the SAIS, and recent advances in establishing its clinical benchmarks further support its use in future studies.

The CMS is also widely used in shoulder conditions due to providing both subjective (activity and pain) and objective (mobility and strength) evaluation of shoulder function and its good inter- and intra-observer reliability (Constant et al., 2008). Both female and male patients had substantially reduced total score (45–60%) as a result of proportional reduction in activity, ROM, and power. The results of this study are comparable with those of Christiansen et al. (2015) who reported a total score of  $54.0 \pm 13.9$  in a large study of 112 SAIS patients undergoing arthroscopic decompression. The same study reported a Minimal Clinically Important Difference (MCID) of 11 points for the CMS to facilitate interpretation of the clinical relevance of the score (Christiansen et al., 2015). Potential advantages of the CMS include long-term data availability and hence allowing for comparisons across conditions, procedures, and time as such population normative values have been established and support score interpretation. A higher CMS at the first evaluation has been linked to good prognosis (Ertan et al., 2015).

The DASH is the most studied questionnaire with an MCID of 10.5 for patients with various upper extremity disorders including SAIS (10.2) (Roh, 2013). MacDermid et al. (2007) reported reduced DASH scores of 40% in SAIS patients which are in line with the present study results. Furthermore, its Substantial Clinical Benefit (SCB) that defines the amount of change associated with SAIS patient perception of a large meaningful improvement has been reported as 40% (Michener, Snyder Valier, & McClure, 2013). The SCB appears to be advantageous over the MCID that reflects only the minimal



patient-rated important change. SCB is of clinical importance as it facilitates the identification and interpretation of substantial changes in the functional capacity of SAIS patients over time and support treatment decision-making for individual patients (Michener et al., 2013).

MPQ was used for multidimensional evaluation of patients' "pain" in terms of location, temporal pattern, description; and present intensity (Melzack, 1975). It has been reported that self-perceived physical performance and function improves alongside with pain reduction which underpins pain experience as a significant mediator of function and disability that needs to be evaluated when identifying changes and intervention outcomes over time (Cook et al., 2011). The study results suggested a greater pain experience for both female and male SAIS patients. While female patients most frequently described pain as throbbing, shooting, and tingling, the most often selected words by the male patients included shooting and annoying. Camargo et al. (2009) studied physical disability and pain experience in industrial workers with SAIS and reported MPQ as an important tool for clinical evaluation of condition.

The self-reported SF-12 has been widely used as an outcome measure in relation to rotator cuff diseases for assessing physical functioning, pain, general health perception, vitality, role limitations due to physical and emotional health problems, social functioning and mental health (Connelly, Shaw, & O'Grady, 2015; Huang, Wang, Wang, Qin, & Sun, 2016). SF-12 indicated major impairment in both physical and mental components in SAIS patients. Despite the fact that the SF-12 is not specific to the shoulder, there are recent indications that SF-12 and SF-36 are the most widely used measures of general health in clinical studies, including shoulder-related conditions, around the globe (Booker, Alfahad, Scott, Gooding, & Wallace, 2015).

Several authors have suggested that a complete understanding of clinical outcomes requires consideration of psychological factors alongside with physical factors as such a healthy psychological status is a strong indicator of the relationship between the physical health/health-related quality of life and self-rated health (Perruccio, Davis, Hogg-Johnson, & Badley, 2011). The HADS has been increasingly used in relation to the common upper extremity conditions such as lateral epicondylitis, rotator cuff tears, and SAIS (Alizadehkhayat, Fisher, Kemp, & Frostick, 2007; Cho et al., 2015). The study found considerably higher levels of anxiety and depression in female and male patients which may in turn affect their functional capacity (Alizadehkhayat et al., 2007; Graven-Nielsen & Arendt-Nielsen, 2008). Psychological predispositions negatively affect outcome measurements in patients with rotator cuff diseases and that pre-intervention psychological distress may lead to patient dissatisfaction and disturb post-intervention recovery (Cho et al., 2013). In an outcome study of rotator cuff repair improvements were reported in depression, anxiety, and sleep disturbance as well as health status, pain, and functional capacity 12 months post intervention. Accordingly, it has been suggested that assessment of key psychological factors may effectively predict clinical outcome following interventions for the management of rotator cuff conditions (Cho et al., 2015).

#### **4.2. Functional assessments (FIT-HaNSA, Muscle Strength, ROM)**

The neck, shoulder, arm, elbow, forearm, wrist and hand influence functional performance of the upper extremity as important components of the integrated kinematic chain (McMullen & Uhl, 2000). FIT-HaNSA provided an indirect assessment of functional performance by means of stability, strength, and motion of the shoulder complex (Neer, 2005). While the FIT-HaNSA has been used by recent studies for determining the upper extremity function in different shoulder pathologies as well as in healthy shoulders, the data on SAIS is limited (Hawkes et al., 2012; Kumta et al., 2012; Roy et al., 2009). Both female and male patients showed significant functional impairment particularly in relation to the EDT component of the FIT-HaNSA possibly due to higher loading demands at the eye level in the presence of considerable weakness, coping with painful arc at the mid-range of movement, and increasing discomfort and sense of instability during early phase of arm lowering. Interestingly, both female and male patients scored relatively better during OHT (designed to assess endurance during a sustained overhead activity without lifting any weight). This is very like because

of the arms in OHT being elevated beyond 120° where the subacromial space widens again resulting in less subacromial pressure and hence less irritation and pain.

Both female and male patients presented with significant weakness in the affected shoulders. The most affected muscles were the shoulder abductors (reduced 51% in female and 38% in male patients) and the least affected muscle group was the external rotators (33% and 23% strength deficit in female and male patients, respectively). The deltoid and rotator cuff muscles provide a smooth trajectory of the head of the humerus during arm elevation according to the “force couple” principle (Inman, Saunders, & Abbott, 1944). Within the coronal plane, the force couple involves deltoids and supraspinatus muscles superiorly and infraspinatus and subscapularis muscles inferiorly (Poppen & Walker, 1978). The major strength deficit found in the present study for shoulder abductors reflects the involvement of the supraspinatus and other components of the rotator cuff in the pathology of SAIS. In fact, the supraspinatus muscle is considered as the most vulnerable muscle to be affected within the subacromial space particularly due to anatomical disadvantages (Neer, 2005; Struyf et al., 2014). Using a hand-held dynamometer, Marcondes et al. (2011) assessed muscle strength of 48 patients with unilateral SAIS of both genders and reported a significant strength deficit in the affected shoulders during scapular plane arm elevation, external rotation, and internal rotation strength (50–65 age range) compared to asymptomatic shoulders. Several other studies have reported significantly lower external and internal rotation strength and related ratios between affected and unaffected shoulders in SAIS patients, external rotation in particular (Marcondes et al., 2011). MacDermid et al. (2004) compared muscle strength of healthy controls and SAIS patients and reported shoulder rotation strength measures, particularly external rotation, as reliable indicators of functional integrity of the rotator cuff muscles and hence potential predictors of functional capacity and quality of life. The present study used an isometric strength measuring technique which has shown to have a high relationship with pain/disability compared to isokinetic techniques (MacDermid et al., 2004).

It was also found that a significant impairment of shoulder mobility particularly within the functional arc exists in both genders at the affected shoulders. While loss of capsular resilience, repeated micro-trauma, and inflammatory reactions have been linked to the movement restrictions in SAIS patients (due to soft tissue tightness in levator scapulae, upper trapezius, pectoralis minor and major); pain-related adaptations, muscle imbalances, and scapular dyskinesis are also suggested to contribute to reduced ROM (Page, 2011). Furthermore, postural misalignments commonly observed in SAIS have been linked to restricted ROM due to increased scapular protraction and anterior tilting by placing the acromion and coracoid process more anteriorly and downwards and hence affecting the functional arc of forward reaching (Struyf, Nijs, Baeyens, Mottram, & Meeusen, 2011). Several 3-dimensional studies have further highlighted the role of altered scapula positioning with arm elevation in relation to SAIS by means of decreased scapular upward rotation, increased protraction, and anterior tilt (Ludewig et al., 2009). The range of internal rotation was the most painfully restricted movement followed by external rotation, abduction, and forward flexion. The limitation of internal rotation in SAIS patients has not been considered sufficiently in the literature despite its important role in daily activities requiring extension and internal rotation of the shoulder to approach back (Kumar & Satku, 1994). A few studies have demonstrated GHJ internal rotation deficit and posterior tightness in patients with SAIS (Tyler, Nicholas, Roy, & Gleim, 2000) potentially due to increased scapular anterior tilting and humeral anterior translations relative to the glenoid (Borich et al., 2006). The significant reduction in the range of external rotation found in the study supports the assumption that restricted humeral external rotation may lead to SAIS (Browne, Hoffmeyer, Tanaka, An, & Morrey, 1990). During arm elevation up to the range of 60°–120° which is associated with the narrowing of the subacromial space and increased subacromial pressure, humeral external rotation allows clearing of the greater tuberosity from the under-surface of acromion in order to avoid the compression of subacromial soft tissues.

### 4.3. Study limitations

Study had some limitations. The sample size was relatively small mainly due to focusing on separate data reporting for female and male groups of patients and controls. This approach was taken based on the evidence suggesting a significant association between SAIS and female gender (Tangtrakulwanich & Kapkird, 2012) and higher prevalence of upper extremity/shoulder pain in females compared to men (22.8–30.9% vs. 13.3–21.4% in the 25–64 years) (Pribicevic, 2012). While there were no statistically significant differences in the demographics between controls and patients for either sex, the relatively higher age in patient groups (female patients in particular) compared to the healthy participants could have partly attributed to the study findings. The study examined and compared the outcome measures in patients with active SAIS symptoms and future studies are needed to evaluate the changes in outcome following common surgical and conservative interventions.

### 5. Conclusion

The increasing interest towards patient-centred healthcare has led to the emergence of numerous outcome instruments for the quantification of functional outcomes in orthopaedic patients. Study reports baseline data for several outcome assessment tools in both healthy controls and patients suffering from SAIS. It was found that both female and male patients were substantially affected by the condition by means of pain experience, functional capacity and performance, psychological status, and quality of life compared to healthy controls. The data support the development of comparative interventional (conservative and surgical) studies aiming to evidence the outcome by facilitating the selection of appropriate measures. In order to develop multidimensional evidence-based interventional strategies for this common upper extremity musculoskeletal condition and to provide clinician with a clear understanding of upper extremity functional abilities, we suggest a combination of subjective and objective upper limb regional/joint-specific pain and functional measures along with suitable psychologic and quality of life assessment tools. The SAIS appears to be associated with abnormal mental status, and therefore future research of clinical interventions should pay equal attention to the psychologic and the physical aspects of the condition.

#### Ethical Consent Statement - Referring to either animal or clinical trial

The study received Local Research Ethics Committee approval (NRES Committee North West – Liverpool Central 08/1005/117) and all participants gave their written informed consent prior to participation.

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#### Competing Interests

The authors declare no competing interest.

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