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SHOULDER

Shoulder activity level in the preoperative assessment of patients with rotator cuff tears

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Abstract The purpose of this study was to investigate shoulder activity level in preoperative assessment of shoulder function and health-related quality of life (QoL) for patients with rotator cuff tears. One hundred and six patients with rotator cuff tears were prospectively evaluated using the following outcome instruments: the Shoulder Activity scale, the Constant scale, the Simple Shoulder Test, and the Short Form-36v2 (SF-36v2). Clinical and structural data, including patients' demographics, comorbidities, duration of symptoms, shoulder contracture, and tear size, were collected and analyzed. We determined that the shoulder activity level was associated with gender, medical comorbidities, and age. Females had lower activity level, worse scores for health-related QoL, and longer duration of symptoms than males. Patients who had severe comorbidities had lower shoulder activity scores and worse SF-36v2 scores compared to patients who did not have such comorbidities. The patient age correlated with the shoulder activity level, but did not have significant correlation with the duration of symptoms and shoulder function. The shoulder activity level was related to patient gender, general health status and age; therefore, further investigation is warranted to determine if the activity level can be used as a prognostic variable relating to outcome in the treatment of rotator cuff tears.

Keywords Rotator cuff tear · Constant scale · Simple shoulder test · Shoulder activity scale · Comorbidities · Shoulder contracture

Ethical Board Review statement: This investigation was approved by the research ethics board. The patients were informed about the study and signed informed consent.

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Introduction

Chronic rotator cuff tears (RCT) are one of the most common pathologies seen in a shoulder surgeon's practice. This pathology is mainly related to degenerative changes in rotator cuff tendons during the aging process [1, 2] and repetitive micro trauma [3]. Some of the patients with RCT are asymptomatic, while others have pain and impairment of shoulder function that cause limitations of activities of daily living (ADL). These patients should be treated either conservatively or operatively depending on duration and severity of the symptoms, general health status, and patients expectations [3].

Previous studies have determined that age, gender, rotator cuff tear size, and medical and social comorbidities are associated with worse preoperative shoulder function and/or health-related quality of life (QoL) [4–7]. Worse clinical outcomes after operative treatment were associated with older patients with poor quality of the tendon [8–12],

fatty degeneration of the muscles [13, 14], and failure to adequately mobilize the tendon [15]. Worse clinical outcomes were also seen for patients with worker's compensation claims [15, 16] and lower preoperative expectations [17], but medical comorbidities did not affect the final shoulder function [18]. These studies did not evaluate shoulder activity level, which may be important as a prognostic factor for surgical decision-making. Looking for new and better prognostic factors for patients with various shoulder disorders, Brophy et al. developed a shoulder activity scale (SAS) for measuring shoulder activity level (SAL) [19]. Developers of the scale hypothesized that SAL could be an important prognostic variable relating to outcome. This variable has not been routinely evaluated and we are not aware of any studies that focused on the SAL as a potential prognostic variable in patients with RCT.

Our hypothesis was that preoperative status (shoulder function and health-related QoL) of patients with RCT is related to SAL. The purposes of this study were: (1) to determine the relationship between the SAL, demographic, clinical, and structural variables in the preoperative patient group with RCT, (2) to evaluate the importance of determined variables and the SAL in preoperative assessment of shoulder function and health-related QoL.

Materials and methods

The original patient group consisted of 113 prospectively evaluated consecutive patients with chronic rotator cuff tears who were admitted to the hospital for operative treatment between April 2007 and January 2008. This investigation was approved by the research ethics board. Patients were informed about the study and signed an informed consent form. Patients who had a clinical diagnosis of RCT confirmed by MRI, shoulder symptoms that had been present for a minimum of 3 months, and ineffective conservative treatment, were selected for operative treatment. From this study, we excluded four patients with bilateral symptomatic shoulders and three patients with previous surgery on the contralateral shoulder. The final group consisted of 106 patients with unilateral symptomatic shoulders. There were 65 (61.3%) males and 41 (38.7%) females. The median age and standard deviation was 56 ± 9.7 years (range 33–78).

Preoperatively, all patients were examined by one operating shoulder surgeon. All items of the Constant scale (CS) (pain, ADL, active external and internal rotation) were evaluated and documented during an interview, and the active range of motion (forward flexion, abduction) was measured with a goniometer [20, 21]. Additionally, shoulder pain was estimated with a 0–10 point numerical scale (NS) by patient recall. The abduction strength was measured in the scapular plane with the arm abducted 90° and the elbow extended using the Kern digital dynamometer (Kern & Sohn GmbH, Balingen, Germany. Weighing range Max. 15 kg, readout $d = 20$ g, reproducibility 20 g, and linearity 0.5%) following a reliable technique [22]. For statistical analysis of the shoulder strength, we used the mean values of three repetitive measurements. For measuring pain, we used the NS scores; for both ADL (0–20 points) and active range of motion (ROM) (0–40 points) we used separate scores from the CS. Shoulder function scores (the mean and standard deviation) for our patient group were: NS pain (5.6 ± 1.9), ADL (7.4 ± 4.3), active ROM (23.2 ± 11.2), strength (kg) 3.1 ± 2.6, and the total CS (out of 100 points) 43 ± 19.0. The mean duration of symptoms was 19.6 ± 57.8 months (range 3–444, median 6 months).

After an observer-based evaluation, all patients completed patient-based questionnaires without assistance. Shoulder function was evaluated using a self-assessment shoulder evaluation tool, the SST, which contains 12 questions [23]. The questions require only "yes" or "no" responses and each question equally weighted at 8.3 points in a 0–100 points scale. The mean score and standard deviation for the SST was 36 ± 21.4 points (range 0–92). For assessment of general health status, the patients completed a questionnaire regarding possible medical comorbidities (back pain, hypertension, degenerative joint disease, heart disease, diabetes, peptic ulcer disease, depression, pulmonary disease, cancer, rheumatoid arthritis, kidney problems, liver problems, and problems with the blood) and severity of these comorbidities. Patients receiving any financial support from national institutions due to one or more illness were defined as having severe comorbidities. Patients were instructed to mark only those diseases that were still present during the current hospitalization. Seventy-seven (72.6%) patients [46 males (60%)] had one or more medical comorbidities and 20 (18.9%) patients (10 males) had severe comorbidities. We did not verify the patients' self-assessment of these comorbidities in any databases or medical records. The frequency of self-reported medical comorbidities for our patient group is reported in Table 1. We measured the SAL using the Shoulder Activity scale [19]. The first part of the scale has numerically scored items, and measures SAL using specific questions about various activities (minimum 0, maximum 20 points in the scale). The other part has two alpha-scored items (sport questions). For statistical analysis, we used the two parts of the scoring system separately.

For evaluation of health-related QoL we used the SF-36v2, which was obtained from the Quality Metric Incorporated Company. The SF-36v2 was developed to measure eight health attributes using eight multi-item subscales. The instrument has two scoring options: 0–100 scoring (transformed scores) and norm-based scoring [24].

Table 1 Frequency of self-reported medical comorbidities for 106 patients with rotator cuff tears

Comorbidity	No. (%) of patients
Back pain	51 (48.1)
Hypertension	45 (42.5)
Degenerative joint disease	20 (18.9)
Coronary heart disease	15 (14.2)
Diabetes	9 (8.5)
Peptic ulcer disease	3 (2.8)
Depression	12 (11.3)
Pulmonary disease	8 (7.5)
Cancer	0
Rheumatoid arthritis	1 (0.9)
Kidney problems	5 (4.7)
Liver problems	2 (1.9)
Blood problems	1 (0.9)

Preoperatively, the transformed scores for separate eight subscales of the SF-36v2 for our patient group were (mean and standard deviation): physical function (PF) 60.05 ± 20.41, role physical (RP) 36.62 ± 21.26, bodily pain (BP) 35.40 ± 17.89, general health (GH) 50.17 ± 19.02, vitality (VT) 56.13 ± 22.29, social function (SF) 61.79 ± 25.87, role emotional (RE) 48.03 ± 25.13, and mental health (MH) 59.81 ± 22.38. All questionnaires were inspected for unanswered items. We detected that 10 patients returned incomplete questionnaires. In each case, the items left unanswered were different. We gave these questionnaires back to the patients, and asked them to review and complete the blank items. After that, we received all questionnaires with no missing data.

A detailed protocol for registering intraoperative findings was developed, and the precise configuration and size of the tear were documented. Open surgery was performed for all patients. The area of the tear (tear size) in centimeters squared was calculated using the base of the tear along the former insertion site times the depth of muscle retraction according to Ellman [25]. Shoulder contracture was documented if the patient under anesthesia had restriction of passive ROM and manipulations before the surgery were performed. The mean size of the tear was 5.6 ± 5.8 cm^2 (range 0–24 cm^2). There were 91 (85.8%) patients whose shoulders had full-thickness tendon tears, 11 (10.4%) with partial, and 4 (3.8%) with massive tears. Eighteen (17%) patients had shoulder contracture.

Statistical analysis

For statistical analysis, we used the raw CS scores (0–100 point scoring) without adaptation to the patient's age and gender, 0–100 point scoring for the SST and 0–100 point scoring (transformed scores) for the SF-36v2. A stepwise linear regression analysis was used to determine relationship between the SAL (dependent variable) and the age, gender, duration of symptoms, shoulder contracture, tear size, the number and the presence of severe medical comorbidities, participation in sports, the SST, the CS, and the scores of eight separate subscales of the SF-36v2 (independent variables). We also evaluated the importance of the SAL, age, gender, and comorbidities in preoperative patient group. Differences between males and females and between patients having severe comorbidities versus those who had no such comorbidities were examined using the independent-samples *t* test or the Mann–Whitney test (for quantitative variables), and the Chi-squared test (for qualitative variables). Correlations of age with parameters of interest were examined using the Spearman correlation test. The level of significance was set at $P = 0.05$. All data analyses were performed with SPSS software (version 16.0 for Windows; SPSS, Chicago, IL).

Results

The mean score and standard deviation for the SAL in the overall patient group was 11 ± 5.4. Seventeen (16%) patients were involved in sports (16 males and 1 female). One patient was a professional athlete, four others participated in sports with organized officiating, and the remaining twelve patients participated in sports only occasionally.

Multivariate regression analysis revealed positive association of the SAL with male gender and negative associations with the presence of severe comorbidities and age. Data (the final step) from the multivariate regression analysis is reported in Table 2. Distribution of the SAL scores by gender and age is demonstrated in Fig. 1.

After stratifying the patient group according to gender, we determined that the SAL scores were lower for female patients ($P < 0.001$) than for males. The mean score and standard deviation for the SAL in female patient group was 9 ± 4.9 and in male patient group was 12 ± 5.2. Additional analysis of the male patient group revealed that the SAL scores were not significantly higher for those patients who were active in sports than those for sedentary patients ($P = 0.261$) which is the rationale for the additional alpha sports score. Male patients had higher the SF-36v2 scores for health-related QoL (Fig. 2), higher total SST scores for shoulder function ($P < 0.001$) (Fig. 3) and shorter duration of symptoms ($P = 0.002$) than females. We found that females had lower shoulder strength than males ($P < 0.001$) and this was the only subscale in the CS which differed between males and females. There were no

Table 2 Data from the multivariate regression analysis

Dependent variable	Independent variable	Regression coefficient	β	P value
Shoulder activity level [$R^2 = 0.207$, adjusted $R^2 = 0.183$, $P_{ANOVA} < 0.001$]	Male gender	3.264	0.297	0.001
	Severe comorbidities	−3.150	−0.230	0.012
	Age (years)	−0.102	−0.183	0.043

R coefficient of determination, β standardized linear regression coefficient

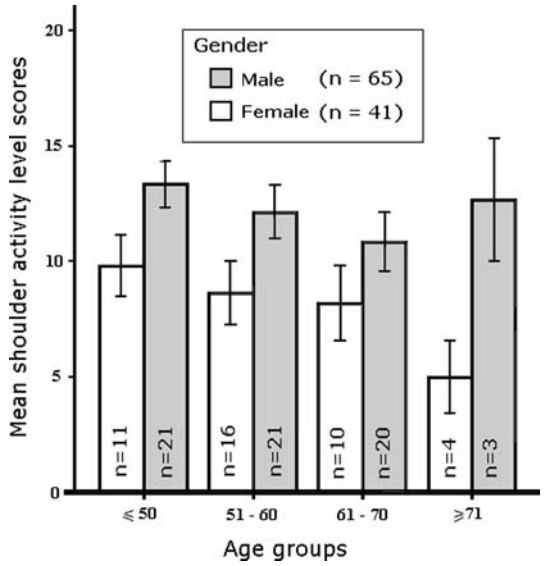

Fig. 1 Bar graph showing distribution of the mean shoulder activity level scores by gender and age. The error bars represent one standard deviation

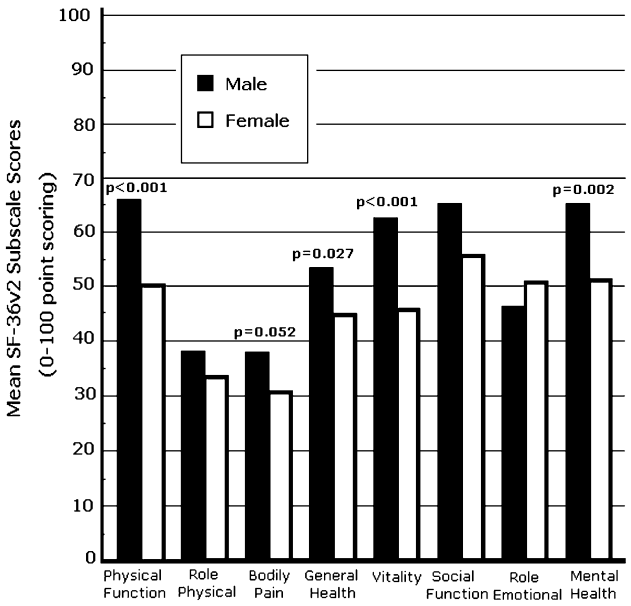

Fig. 2 Bar graph showing the mean Short Form-36v2 subscale scores for males ($n = 65$) and females ($n = 41$) with rotator cuff tears

differences in the total CS scores between males and females ($P = 0.142$).

The twenty patients with severe comorbidities had lower SAL scores ($P = 0.005$) than those who had no such comorbidities (the mean and standard deviation for the SAL was 8 ± 6.2 vs. 12 ± 4.9). They also had longer duration of symptoms ($P = 0.027$) and worse scores on all eight subscales of the SF-36v2 [PF, GH and VT ($P < 0.001$); SF ($P = 0.001$); RP ($P = 0.007$); MH ($P = 0.005$); RE ($P = 0.025$), and BP ($P = 0.040$)], but did not have significant differences between the SST ($P = 0.175$) and the CS ($P = 0.583$) scores. Patient age ($P = 0.098$) and gender ($P = 0.248$) were not significantly different between patients who did or did not have severe comorbidities.

Patient age correlated with the SAL ($r = -0.208$; $P = 0.033$) but not with the duration of symptoms ($r = 0.076$, $P = 0.437$), the total CS scores ($r = -0.021$; $P = 0.831$), or the total SST scores ($r = -0.093$; $P = 0.344$) for shoulder function. There was a correlation with subscale GH of the SF-36v2 ($r = -0.246$; $P = 0.011$) for health-related QoL.

Discussion

Previous clinical studies have determined that age, gender, rotator cuff tear size, medical and social comorbidities are associated with worse preoperative shoulder function and/or health-related quality of life (QoL) [4–7]. We examined the SAL in a preoperative patient group with RCT and the most important finding of the present study was that this variable correlated with patient age, general health status, and gender.

The mean SAL in our cohort of patients with rotator cuff tears was very similar to the SAL reported in a follow-up study by Brophy et al. [26] looking at individuals with a variety of shoulder disorders including rotator cuff tears, osteoarthritis, and instability. In that study, they reported a mean SAL of 10 ± 5.1 in 86 patients with rotator cuff tears, very similar to our value of 11 ± 5.4. However, patients in the present cohort were much less likely to be involved in contact or overhead sports.

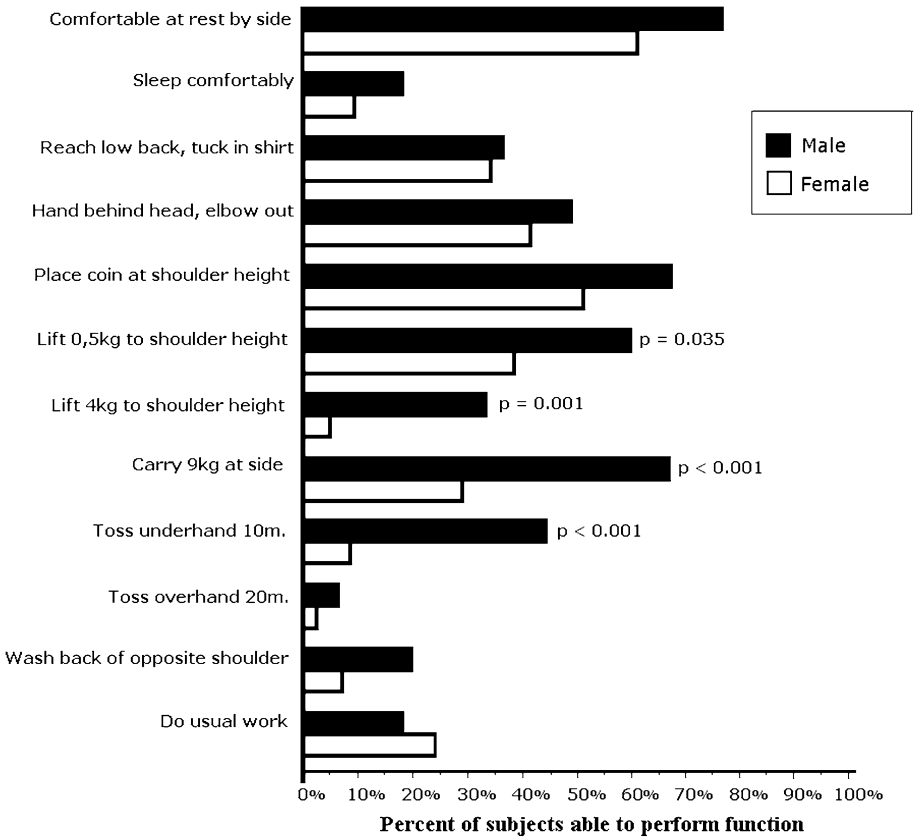

Fig. 3 Bar graph represents differences in responses between males ($n = 65$) and females ($n = 41$) to the 12 items of the Simple Shoulder Test

Patient age was significantly correlated with the SAL ($r = -0.208$; $P = 0.033$), contrary to the initial study of the SAL [19] where the correlation was not significant ($r = -0.09$; $P = 0.58$). However, a follow-up study by Brophy et al. [26] looking at individuals with a variety of shoulder disorders including rotator cuff tears, osteoarthritis, and instability did find a significant negative correlation with age, and a correlation with the type of pathology. Although older patients were less active in that study, there was still a wide range of SAL in the older patients. Correlation of patient age with the SF-26v2 subscale GH supports this finding as older patients usually have lower general health status and lower physical activity level. The initial study of SAL had a smaller and younger group of normal individuals [19]. The recent studies of SAL in patients with shoulder disorders had larger cohorts involving older patients [26].

It was expected that physical activity level (and the SAL) will depend on the patient's general health status evaluated according to the number of medical comorbidities, but the number of medical comorbidities had no association with the SAL. It is possible that, in general, our patients were healthier than reported and might overestimate the number of medical comorbidities. The system of self-reporting medical comorbidities seems to be imprecise because patients might mark diseases on the form that were never diagnosed by a doctor. Additional reviewing of patients' medical records is advisable to assess the comorbidities and severity of the illness [27, 28]. We registered the presence or absence of severe comorbidities by asking the question: "Do you receive any financial support from the national institutions due to one or more illnesses?" This is a clearly defined situation, and every patient knows how to answer to this question. Financial support is granted by a medical board exclusively for patients with severe illnesses. Our study showed that the severity of medical comorbidities may describe a patient's general health status and physical activity level better than the number of medical comorbidities.

In the present study, patient gender had the strongest association with the SAL. Female patients were less active, had worse health-related QoL and their shoulder strength was weaker than that of male patients. Furthermore, female patients had a longer duration of symptoms prior to surgery. While these gender findings may not be generalizable across different countries and cultures, the two previous studies of SAL had not investigated the potential relationship between gender and SAL [19, 26]. Reviewing the data from the prior study of patients with a variety of shoulder disorders [26], females did have an overall lower level of SAL (F 13 vs. M 15). This difference was less pronounced, however, among patients with rotator cuff

tears (F 14 vs. M 16). Based on these findings, further investigation into gender-based differences in SAL is warranted.

Since, occasional sports do not significantly alter the SAL scores, sports are evaluated by a separate alphabetical scale [19]. Additional analysis of male patients established that the SAL scores were not higher for those patients who were active in sports than those for sedentary patients. However, the present study had lower sports participation (16%) than the previous studies of SAL, and only included one professional athlete. Almost twice as many patients participated in sports (31%) in the study looking at patients with a variety of shoulder disorders [26], even among the patients with rotator cuff tears (29%).

The first limitation of this study is the lack of data regarding the clinical relevance of SAL. Another limitation is that it only looked at the relationship between SAL and preoperative factors in a cohort of patients with RCT. The relationship between SAL and postoperative results was not explored. As shown previously [26], the results in different patient populations with different shoulder pathologies such as shoulder instability or osteoarthritis may be different. The third limitation was the exclusion of other important independent variables such as smoking and alcohol use. The educational level of the patients might also be important as individuals with lower literacy levels may be less able to comprehend the questions in the self-assessment instruments.

Conclusion

In conclusion, SAL was related to patient gender, general health status, and age in a large cohort of patients undergoing surgical treatment for RCT. In this cohort, males tended to be more active than females and younger patients were more active than older patients. Severe comorbidities were associated with a lower SAL. Further investigation is warranted to determine if SAL is useful in other shoulder disorders and whether it can be used as a prognostic variable relating to outcome in the treatment of RCT.

Conflict of interest statement The authors have not signed any agreement with a commercial interest related to this study which would in any way limit publication of any and all data generated for the study or to delay publication for any reason.

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