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SECTION II
ORIGINAL ARTICLES

Measurement of Shoulder Activity Level

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There are many measurement tools for assessing patients' shoulder symptoms (pain) and function (what patients can do), but they do not measure activity (how often a patient engages in activity). This is relevant because activity level can have an important impact on a patient's outcome. Our goal was to develop a short, easy to administer measure of shoulder activity which could be used to predict outcome of shoulder disorders. The activity scale was developed using established principles: item generation, item reduction, pretesting, and reliability and validity testing. The activity rating is a numerical sum of scores for five activities rated on a five-point frequency scale from never performed (0 points) to daily (4 points). Patients were scored on the following criteria: carrying an object 8 lb or heavier by hand, handling objects overhead, weight training with arms, swinging motion (ie, hitting tennis or golf ball), and lifting objects 25 lb or heavier. Two additional multiple choice questions provide a score assessing participation in contact and overhead sports. The activity scale showed excellent reliability and construct validity. It can be completed quickly and used in conjunction with patient-based measures of shoulder outcome to define patient populations for cohort studies, and to assess activity level as a prognostic factor in patients with shoulder disorders.

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Each author certifies that his institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.
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During the last two decades measurement tools for evaluating patient function have become more common in orthopaedics.[29] Most tools are designed to quantify patient symptoms or functional disability or both because other traditional objective measures do not capture these data. Although symptoms and function relate to patient activity level, measures of symptoms and function do not capture the patient's activity level. Function typically reflects how well a patient does certain tasks and activity level measures how much a patient does.

The use of activity scales in orthopaedics is increasing, and various activity rating scales are available for disorders of the knee[6,20,24,30] and ankle.[13] There is a need for a validated questionnaire evaluating patient activity.[9] Two patients with different levels of activity may have similar levels of pain (symptoms) and limitations of function after an identical injury. However, for several reasons their postoperative outcome could be different based on their level of activity. First, patient level of activity may influence the biologic success of treatment. For example, an overhead painter will stress a rotator cuff repair more heavily than a sedentary retiree. Second, level of activity may influence patient perception of treatment success. If treatment relieves night pain for a patient with low activity, they may be satisfied with the outcome. However, a more active patient expects restoration of previous activity level to attain a similar level of satisfaction. Therefore, patient activity level could be an important prognostic variable relating to outcome.

There is a need for better prognostic predictors in patients with shoulder disorders because few, if any, factors

have been shown as prognostic variables[16] for patients with shoulder disorders. There is weak evidence supporting some outcome predictors, including heavy and unusual activities of the upper extremity.[32] Although there are various instruments that measure function and disability of the upper extremity, no specific measure of shoulder activity has been described. Neer pioneered documentation of shoulder outcome with his results of anterior acromioplasties in 1972,[22] and in 1982, Neer et al[23] documented results of total shoulder arthroplasties. The analysis included patients' self-rated ability to do numerous personal grooming tasks, to use the arm at shoulder level, and to carry 10–15 lb with the arm at the side. However, the analysis did not serve as an activity rating scale because it did not indicate how often the patients engage in reported activities. Numerous shoulder questionnaires have been developed since then: the Rowe Rating Sheet for Bankart Repair[28] developed in 1978, the Constant and Murley Shoulder Score[3] developed in the mid1980s, and additional measuring instruments.[4,5,7,10,14,15,17,18,21,26,27,31,33] However, they do not evaluate how active patients are with their shoulders. A review of shoulder disability questionnaires[2] did not include any instrument that measured patient activity (ie, an activity rating scale).

The purpose of our study was to develop a rating scale to measure shoulder activity that could be self administered, completed by patients within 1 minute, and easily generalized across different sports and daily living activities. The rating scale would evaluate the role of activity as a prognostic variable in shoulder disorders.

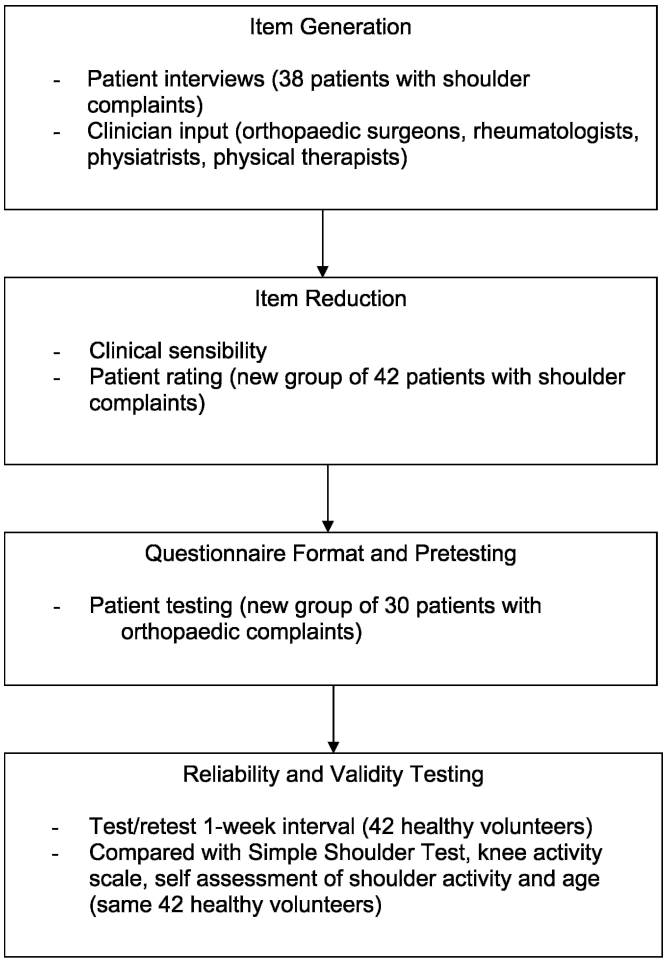

Fig 1. A flow chart shows the four steps in developing the shoulder activity scale: item generation, item reduction, questionnaire format and pretesting, and reliability and validity testing.

MATERIALS AND METHODS

The activity scale was developed by applying commonly accepted principles[12]: item generation, item reduction, questionnaire format, pretesting, and reliability and validity testing (Fig 1). Item generation identified reasonable activities for inclusion in the activity scale. Then, item reduction selected the subset of the initially generated items to be included in the activity scale. A questionnaire format was prepared based on those items. The scale then was pretested[12] to arrive at an easy to understand version before reliability and validity testing. Appropriate Internal Review Board approval was obtained before patient interviews.

We began item generation by surveying patients with shoulder disorders to identify items that they considered relevant to their shoulder disorder. Patients were asked while in the waiting room if they would be willing to participate in this study. Patients who agreed were interviewed with the following three oral questions: (1) What activities do you do which use your shoulder? (2) What activities would you like to do but cannot because of your shoulder? and (3) What is the most strenuous activity or sport you do? One interviewer recorded all responses. To include as many relevant items as possible, we interviewed three orthopaedic surgeons who specialize in disorders of the shoulder, two rheumatologists, two physiatrists, and two physical therapists who treat patients with shoulder disorders. We asked them to identify possible items for inclusion in the activity scale.

We wanted to create a 5–10 item list so patients could complete the activity rating scale in 1–2 minutes. Based on the clinical sensibility[11] (the judgment of clinicians with expertise in the domain under study) of the clinicians involved in item generation, we condensed the initial activities into a smaller subset of questions. A new group of patients with shoulder complaints, selected from the practice of two orthopaedic surgeons specializing in sports medicine and shoulder disorders, were asked to review the items regarding specific activities and to rate the importance of each item and the difficulty they had with each item on a scale of 1–10. The importance and difficulty scores were added for each item,[19] and we reduced these items to a smaller final set to be included in the questionnaire. By limiting the number of items, responder burden is minimized, and general

use of the instrument with health outcome instruments is facilitated.

Some activities related to sports depended on the frequency and level of sporting competition. Therefore, some questions related to sports activity were included in a multiple-choice format for a more descriptive picture of the patient's activity level. Patients could answer each multiple choice question: (A) No; (B) Yes, without organized officiating; (C) Yes, with organized officiating; or (D) Yes, at a professional level (ie, paid to play). The categories were designed to reflect the frequency and intensity of sports activity, increasing from A–D. Differentiating the level of sports activity attempts to capture intensity and frequency without making the questionnaire too lengthy or complex.

The items then were formatted as a questionnaire and pretested on patients selected by the interviewer at random from the waiting room of two orthopaedic surgeons to assess patient comprehension and ease of administration. The questionnaire format and wording was modified in response to patient feedback after every 10 patients.

For test-retest reliability we required a new sample of 40 healthy individuals[8] who were selected from the general population and who were not involved in the study design or execution. The subjects completed the shoulder activity scale and were asked to complete the scale again after a 1-week interval. They were not shown their previous responses when they completed the scale for the second time. Reliability was measured using the intraclass correlation coefficient.[1]

Testing for criterion validity (how accurate an instrument is with respect to a reference standard[11]) could not be done because of lack of an accepted standard for comparison. The input of expert physicians and physical therapists corroborated face validity (the overall reasonableness and sensibility of an index[11]) and content validity (appropriate selection and aggregation of components qualitatively[11]). We tested construct validity (how well an index describes the construct it is intended to assess[11]) on the same individuals who completed the reliability testing by comparing results on our activity scale with results from a lower extremity activity rating scale,[20] the Simple Shoulder Test[18] (measures overall shoulder function), and self-reported shoulder activity and age. Although the activity rating scale used for comparison focused on the knee,[20] we anticipated a positive correlation as both scales measure an aspect of patient activity. We also anticipated a positive correlation with the Simple Shoulder Test.[18] Patients with greater shoulder activity levels (as measured by our scale) were expected to have better shoulder function. However, because of the distinction between function and activity, we expected some divergence between the activity scale and the Simple Shoulder Test.[18] Patients were asked about their shoulder activity level. We asked patients to circle a number on a 10-point scale ranging from 0 (not active) to 10 (extremely active). We presumed our scale would positively correlate with the subjects' self-reported shoulder activity level. For divergent validity, the new scale was correlated with patient age. Older patients were expected to have lower activity scores (inverse correlation). The Spearman correlation coefficient was used for all correlations as all scales were based on ordinal data.

RESULTS

Based on our patient interviews and survey of practitioners who treat patients with shoulder disorders, item generation resulted in 49 activities to be considered for possible inclusion in the activity scale. After the first 18 patient interviews, no new activities were generated. We continued the interviewing process for an additional 20 patients, and after 38 patients, we were satisfied that no new items would be identified. The patients included 22 men and 16 women (range, 19–74 years; mean, 48 years) with various shoulder diagnoses and complaints including rotator cuff tear (16 patients), shoulder pain (six patients), instability (five patients), impingement (four patients), adhesive capsulitis (three patients), and other diagnoses. Patients were captured at different phases of evaluation and treatment from initial office visits to postoperative followups. Applying clinical sensibility to the initial data from patients and clinicians, we condensed the initial 49 activities into 10 questions regarding specific activities and two sports-related questions. These were analyzed separately because they applied to very specific patient populations.

The sports questions were in multiple choice format to capture frequency and intensity of activity. The first sports question is: "Do you participate in contact sports (such as, but not limited to, American football, rugby, soccer, basketball, wrestling, boxing, lacrosse, martial arts, etc)?" Participation in contact sports can be particularly relevant for patients with shoulder instability and is an important item in the activity rating scale. The second question is, "Do you participate in sports that involve overhand throwing (such as baseball, cricket, or quarterback in American football), overhead serving (such as tennis or volleyball), or lap/distance swimming?" Playing overhead sports is a specific activity for some patients and should be measured.

Item reduction decreased the 10 specific activity items to five (Table 1). We interviewed 42 new patients[12] with shoulder complaints, including 23 men and 19 women (average age, 50.4 years; range, 25–75 years). The most common diagnoses were rotator cuff tears (18 patients), impingement (13 patients), and instability (four patients). The patients had a range of presentations from initial office visits to final postoperative visits. The activities with the three lowest scores (Items 8–10) were eliminated from consideration for the final questionnaire. Based on a combination of clinical judgment and low mean difficulty scores, Items 4 and 6 were eliminated. Items 1 and 5 were modified before reliability and validity testing to include an objective weight rather than the subjective heavy. For Item 1, 8 lb was chosen; the same weight used in the Simple Shoulder Test.[18] For Item 5, 25 lb was chosen to distinguish between patients who routinely do physically demanding manual labor and the average individual who

TABLE 1. Item Reduction with Mean Importance and Difficulty Scores for 10 Activities from Item Generation

Activity	Mean Importance Score	Mean Difficulty Score	Sum of Mean Importance and Difficulty Scores*
1. Carrying objects as heavy as, or heavier than, a bag of groceries‡	7.9	5.2	13.1
2. Handling objects overhead†	6.5	6.2	12.6
3. Weight lifting or weight training with arm†	5.6	6.1	11.7
4. Moving hand to head (as in brushing hair, putting food in mouth, or brushing teeth)‡	8.5	3.2	11.7
5. Repetitive or heavy lifting (at home or work)‡	5.3	5.7	11.0
6. Swinging arms at side (as in skiing, brisk walking, or running)‡	7.6	3.1	10.7
7. Swinging motion (as in hitting a tennis, golf, baseball, or similar object)†	5.2	5.3	10.5
8. Pulling heavy objects across floor (as in luggage)	5.4	5.0	10.3
9. Driving	7.1	3.0	10.1
10. Pushing heavy objects across floor	4.3	4.3	8.6

*Figures may not sum exactly because of rounding errors. †Included in final scale; ‡Modified and included in final scale; §Excluded from scale because of low difficulty score

occasionally lifts a 25-lb object. Examples of common, everyday objects were added to Items 1 and 5 to help patients estimate weight.

After pretesting 30 patients (14 men, 16 women), the final activity scale (Fig 2) included five choices for frequency of each of the five activities: never or less than once a month, once a month, once a week, more than once a week, and daily. Each of the five activity items was scored from 0–4, with one point allocated for each category of increasing frequency. For example, if a patient responded "never or less than once a month" for one of the items, they scored 0 points for that item; once a month, 1 point; once a week, 2 points; more than once a week, 3 points; and daily, 4 points. The total numerical activity scale score is the sum of the individual activity scores, ranging from a minimum score of 0 points (a patient who answers never or less than once a month for all five items) to a maximum score of 20 points (if the patient answered daily for all five items). Patients were asked to select a frequency that reflected their healthiest, most active state during the last year. In addition to the numerical score, each patient received a two-letter score based on his or her responses to the two sports-related multiple choice questions: (A) No; (B) Yes, without organized officiating; (C) Yes, with organized officiating; or (D) Yes, at a professional level (ie, paid to play).

The activity scale showed reliability and validity on a set of 42 healthy individuals (average age, 33.5 years; range, 21–63 years). The mean numerical score of the initial response was 11 [standard deviation (SD), 4.9; range, 2–20] (Fig 3). The test-retest reliability after 1 week for the numerical score was excellent with an intraclass correlation coefficient of 0.92 (Fig 4). Intraclass correlation coefficient values greater than 0.75 indicate good reliability, and values greater than 0.90 ensure reliability reasonable for clinical measurements.[25] For multiple choice Question 1, 69% answered A, 21% answered B, 10% answered C, and 0% answered D. For Question 2, 60% answered A, 33% answered B, 7% answered C, and 0% answered D. Because of the skewed distribution, the kappa statistic for the two questions could not be calculated for reliability. Qualitatively, the answers were identical in 40 of 42 individuals for each question, and the other responses differed by one letter. The scale was significantly correlated ($p < 0.01$) with the other scales studied (self-reported activity score, $r = 0.52$; Simple Shoulder Test,[18] $r = 0.46$; and the knee activity rating scale,[20] $r = 0.66$). The shoulder activity scale was not significantly correlated with age ($r = -0.09$; $p = 0.58$).

DISCUSSION

The clinical instruments related to the shoulder which have been described in the literature do not include a shoulder activity rating scale.[2–4,5,7,10,14,15,17,18,21–23,26,27,28,31,33] Our study addresses this deficiency by presenting a measure of shoulder activity. By focusing on specific components of function as opposed to activities, the scale is designed for patients engaging in various activities and sports. Patients can complete the questionnaire quickly and efficiently, allowing measurement of outcome and general health status.

Measuring patients' shoulder activity is challenging because of the wide range of patient function, from elderly patients with advanced arthritis to competitive athletes with overuse or traumatic injuries. The shoulder activity rating scale is intended to measure patients' activity levels across this wide range. It also is designed to measure what and how much patients are doing rather than how much

Please indicate **with an "X"** how often you performed each activity in your healthiest and most active state, **in the past year.**

	Never or less than once a month	Once a month	Once a week	More than once a week	Daily
Carrying objects 8 pounds or heavier by hand (such as a bag of groceries)					
Handling objects overhead					
Weight lifting or weight training with arms					
Swinging motion (as in hitting a tennis ball, golf ball, baseball, or similar object)					
Lifting objects 25 pounds or heavier (such as 3 gallons of water) NOT INCLUDING WEIGHT LIFTING					

For each of the following questions, please **circle the letter** that best describes your participation in that particular activity.

1) Do you participate in contact sports (such as, but not limited to, American football, rugby, soccer, basketball, wrestling, boxing, lacrosse, martial arts, etc)?

   A No
   B Yes, **without** organized officiating
   C Yes, **with** organized officiating
   D Yes, at a professional level (ie, paid to play)

2) Do you participate in sports that involve hard overhand throwing (such as baseball, cricket, or quarterback in American football), overhead serving (such as tennis or volleyball), or lap/distance swimming?

   A No
   B Yes, **without** organized officiating
   C Yes, **with** organized officiating
   D Yes, at a professional level (ie, paid to play)

Fig 2. A copy of the final shoulder activity scale is shown. It includes five numerically scored items and two alpha scored items.

difficulty patients have with specific tasks. This distinction is relevant because the level of activity may be an important prognostic variable that should be considered when measuring effectiveness of clinical interventions.

This scale is not intended to measure a level of activity for each patient at a particular moment in time; it is intended as a discriminative instrument as opposed to an evaluative instrument. Patients are asked to report their greatest level of activity during the previous year to obtain a better measure of their level of shoulder activity. Their most recent level of activity may be limited by other factors such as weather, conflicting commitments, or complicating illness or injury. The patients' greatest activity level during a 1-year period is likely to be the most accurate.[20]

The activity scale has a wide distribution of scores across individuals. This shows the ability to distinguish between various activity levels (Fig 3). A reasonable interpretation of the numeric activity score is: high, $\geq$ 16 (mean + SD); average, 7–15; and low, $\leq$ 6 (mean – SD). The correlation with assessments of shoulder function and knee activity support the validity of the shoulder activity scale, given that the lack of an accepted standard for shoulder activity makes determination of validity difficult. The shoulder activity scale had a greater correlation with the knee activity scale than with other shoulder instruments, suggesting that the other instruments do not accurately assess activity. The activity scale is clearly reproducible based on the excellent test-retest reliability.

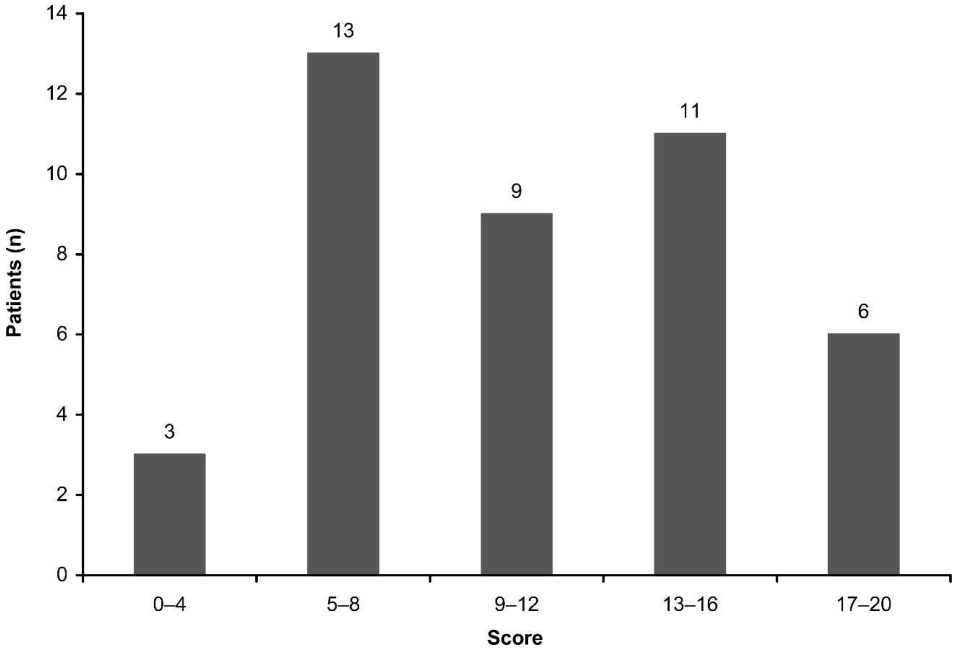

Fig 3. A graph shows that the range of scores on the shoulder activity rating scale approached a normal distribution.

There are several limitations to the methods used to develop the scale. First, the clinical sensibility of the experts involved in developing the scale was a key component of item generation and reduction. Although these experts came from various fields including orthopaedic surgery, rheumatology, physiatry, and physical therapy, the number of experts were limited to two or three in any given field. Such a small sample size may raise concerns as to the sensitivity and validity of the expert opinion. However, the driving force behind item generation and reduction primarily was based on patient data, and the chief role of the experts was to interpret and summarize these data, although a complete rigorous quantitative analysis of each item and subscale was not done. Completing such an analysis of the scale and its items is necessary to fully validate the scale.

Another limitation of our study is testing the validity and responsiveness of the scale in a healthy population. Although it is unclear if validity would differ in patients with shoulder disorders, it is plausible that reliability would differ in individuals with shoulder disorders compared with healthy individuals. However, respondents are

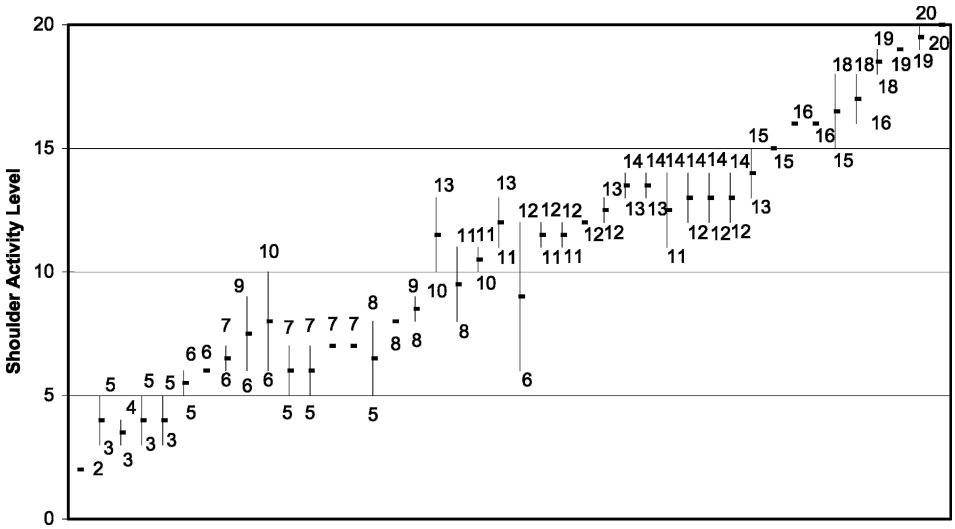

Fig 4. A chart shows the numeric test-retest scores for each individual. It shows the excellent reliability of the shoulder activity scale. If only one score is shown, the test-retest scores were identical.

asked to select their greatest level of activity during the last year, which minimizes the impact of a 1-week interval. This is intended as a discriminative instrument as opposed to an evaluative instrument. Also, although multiple choice questions were used as a separate sports module, the psychometric properties of the sports module were not tested. Additional investigation into this issue may be warranted.

The activity scale has not been shown to have any prognostic value. However, we intend to present the scale for generalized use in patients with shoulder disorders. A reasonable assessment of prognostic value would focus on a specific subset of patients and risk limiting the consideration or use of this scale to that subset. This leaves an obvious opportunity for a followup investigation using this scale in subsets of patients with specific shoulder disorders to determine the prognostic value, if any, of the scale.

The shoulder activity rating assigned to each patient can be used as a patient variable or descriptive characteristic to help stratify patients within a study or across different studies. This is important for clinical research relating to shoulder disorders in two major ways. First, the level of shoulder activity is a potential descriptor of the cohort. For example, the outcomes of rotator cuff repair on a population of middle-aged patients may differ if one group is a more active, sports-oriented group compared with a more sedentary group. Second, the activity rating scale can help assess whether patient activity level influences the efficacy of interventions. For example, a sedentary office worker may have a different outcome after rotator cuff repair compared with a more active, sports-oriented patient. Including a reliable and valid measure of shoulder activity may improve the quality of clinical outcome studies involving the shoulder, and evaluate activity level as a prognostic variable for patients with shoulder disorders.

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