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Assessment of function in patients with rotator cuff tears: Functional test versus self-reported questionnaire

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ABSTRACT

Purpose: The rotator cuff tears (RCT) are a well-known cause of shoulder pain and loss of upper extremity function. The purpose of this study was to evaluate the upper extremity function using two different methods in patients with RCT and to determine the parameters that influence the upper extremity function.

Materials and Methods: A sample of 38 patients (27-76 years; 10 men and 28 women) who were diagnosed with a chronic full-thickness RCT, confirmed by magnetic resonance imaging (MRI), was studied. Upper extremity function was determined using Western Ontario Rotator Cuff Index (WORC) and 9 Hole Peg Test (9PEG). Other assessments included active range of motion (ROM), muscle strength, shoulder pain, and scapular dyskinesis.

Results: There was a weak association between WORC scores and 9PEG. A statistically significant, negative relationship was found between 9PEG and ROM in supination, as well as muscle strength of shoulder extensors, adductors, internal and external rotators.

Conclusions: In addition to the weak association between WORC and 9PEG, the difference between the parameters related to each method suggests that they should not be used interchangeably to determine the upper extremity function. We recommend the utilization of 9PEG instead of WORC in assessing the upper extremity function in the setting of loss of muscle strength.

Level of Evidence: Level IV, Therapeutic study.

Key words: 9 Hole Peg Test, function, rotator cuff tear, upper extremity, Western Ontario Rotator Cuff Index

INTRODUCTION

Rotator cuff tears (RCT) are a common problem causing shoulder pain and loss of upper extremity function. Several factors such as pain, tissue injury, muscle strength and limited range of motion (ROM) may influence the overall upper extremity function.[1,2]

The most commonly administered outcome tools in patients with RCT have been reported as the American Shoulder and Elbow Surgeons (ASES), Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire, Shoulder Pain and Disability Index (SPADI) and Simple Shoulder Test.[3] Although the psychometric features of these measures are appropriate for clinical use, absolute standard error has to be re-evaluated during the measurement of some parameters. Not only are these measures focused on a relatively small number of clinical parameters, but they also lack the sensitivity to detect subtle clinical differences.[4] Therefore, it was suggested that these self-reported outcome measures are not adequate for determining the functional status and disability.[5] In a recent review, including 38 shoulder-specific outcome questionnaires,

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it was pointed out that no gold standard exists among these measures in terms of determining shoulder function precisely.[6]

In the majority of the previous studies, the upper extremity function was determined by the use of self-reported questionnaires in patients with RCT. There only exist a few methods in the literature that evaluate the upper extremity function based on performance, and this group includes FIT-HaNSA, 9 Hole Peg Test (9PEG) and Purdue Pegboard.[4,7,8] Some of the recent studies have focused on determining the upper extremity function with one of these objective methods in different patient populations. For this purpose, FIT-HaNSA has been utilized in several shoulder pathologies, as well as in healthy shoulders.[9,10]

In this study, 9PEG was used to determine the upper extremity function objectively. In addition, Western Ontario Rotator Cuff Index (WORC) was used as an outcome measure to determine the condition-specific functional status and to gather comparative data. The WORC index is a valid and reliable 21-question outcome measurement tool with each question scored 0-100 (maximum raw score 2100, then scaled to 100).[11] Its validation was performed using the University of California at Los Angeles Shoulder Scale, ASES Index, DASH index, and SF-36.[12] Pursuit analyzed include physical symptoms (6 items), sports and recreation (4 items), work (4 items), lifestyle (4 items), and emotions (3 items).[11]

9 Hole Peg Test is a standardized, validated method with normative values in a wide age range that is widely administered to determine the hand and upper extremity function in patients with RCT, as well as healthy adults.[7,13-15] It involves picking up nine pegs from the holes one at a time and placing them in until all nine holes are filled. It is a practical, performance-based clinical tool that is used to evaluate the upper extremity function in different patient groups.[16,17]

The purpose of this study was to evaluate the upper extremity function in patients with RCT by two different methods (WORC and 9PEG) and to determine the parameters that have influence on each method. We hypothesized that there would be no significant association between these methods and therefore, it would not be appropriate to use them interchangeably to determine the upper extremity function, particularly in the group of patients with loss of muscle strength. Simultaneously, the answer of the following questions will be sought in this study:

1. Are the WORC and 9PEG alternatives of each other?
2. May WORC determine ROM losses and shoulder muscle strength weakness itself?

MATERIALS AND METHODS

This study was approved and performed in accordance with the guidelines of the institutional review board at our university, and all patients gave written informed consent to participate in the study beforehand. A sample of 38 patients (mean age, 53.93 ± 10.87 years [range, 43.06-64.8]; mean height, 1.72 ± 0.10 m; mean mass, 72.53 ± 12.78 kg; 10 men and 28 women) with a diagnosis of chronic (>3 months) full-thickness RCT was enrolled in the study (between the years 2011 and 2012). The educational breakdown of patients included 18 university/high school graduates (48.1%), 17 primary school graduates (44%) and 3 illiterate patients (7.9%). 26 patients (68.4%) were housewives while the rest had different occupations. Patient demographics is shown in Table 1.

Inclusion criteria were full-thickness RCT causing typical signs and symptoms associated with shoulder impingement and rotator cuff tendinopathy for 3 months or more. Patients were excluded if they exhibited any neurologic condition resulting in muscle weakness or decreased ROM had a history of prior shoulder surgery and rheumatoid arthritis. Other exclusion criteria were acute RCT; bilateral RCT; glenohumeral joint osteoarthritis and adhesive capsulitis.

Radiological assessment

The tear sizes were classified according to the system described by Cofield *et al.*[18] Involvement and retraction of the rotator

Table 1: Patient and tear demograrphics[#]

Age, mean±SD	53.93±10.87
Involved shoulder, *n*, (%)	
Right	18 (47.37)
Left	20 (52.63)
BMI, w/cm^2, mean±SD	28.31±7.64
Gender	
Male	10 (26.3)
Female	28 (73.7)
Degree of tear retraction	
Minimal	22 (57.9)
Midhumeral	14 (36.8)
Glenohumeral	1 (2.6)
Medial to glenoid	1 (2.6)
Tear size	
Only supraspinatus	30 (78.9)
Supraspinatus+infraspinatus	4 (10.5)
Supraspinatus+subscapularis	3 (7.9)
Supraspinatus+infraspinatus+subscapularis	1 (2.6)
Muscle atrophy	
Normal muscle	11 (28.9)
Muscle>fat	22 (57.9)
Muscle=fat	4 (10.5)
Muscle<fat	1 (2.6)
Humeral head migration	
No	30 (78.9)
Acromiohumeral space >7 mm	
Yes	
Acromiohumeral space <7 mm	8 (21.1)
Humeral head cysts	
Absent	24 (63.2)
Present	14 (36.8)

[#]Values presented as *n* (%) unless otherwise indicated; SD = Standard deviation; BMI = Body mass index

cuff tendons were assessed with the standard, noncontrast coronal, axial and sagittal MRI sequences, as described by Boileau *et al.*[19] The presence of humeral head migration was evaluated on true anteroposterior shoulder radiographs (positive if acromiohumeral distance >7 mm).[20] The fatty degeneration of the rotator cuff musculature was graded on the system described by Goutallier *et al.*[21] The presence of cystic changes in rotator cuff footprint (major and minor tuberosities) was also recorded based on MRI findings.

Upper extremity function

Upper extremity function was determined by 9PEG and WORC.[7,22] The patients were asked to complete the WORC form depending on their quality of life in last 2 weeks. For 9PEG, the patients were asked to pick up the pegs with their affected side and place them in the holes, while holding the board with their unaffected side. The elapsed time was recorded in seconds.

Range of motion

Active shoulder flexion, extension, internal and external rotation as well as elbow flexion and extension were measured in the supine position, while active shoulder elevation was measured in the standing position with a universal goniometer.

Muscle strength

The muscle strength of shoulder flexor, extensor, internal and external rotators, abductor and adductors (with arm in neutral adduction and elbow in 90° flexion), and elbow flexor and extensors were measured with a digital hand dynamometer (Baseline®) according to the criteria of American Academy of Orthopedic Surgeons. Supraspinatus muscle strength was determined in full can position.[23] Hand grab strength was measured with a hand dynamometer (Baseline®), while triple and lateral finger grab strength were measured with a pinchmeter (Baseline®) in the standard position proposed by American Society of Hand Therapists.

Pain

Patients were asked to mark their current shoulder pain on a visual analog scale (range from 0 to 10). They rated their pain at rest, at night, while carrying 2-3 kg packages and in shoulder elevation >90°.

Scapular dyskinesis

Scapular dyskinesis was assessed by observation during bilateral shoulder elevation, according to the classification described by Kibler and Sciascia.[24]

Statistical analysis

Overall summary statistics were assessed for normality and the means and standard deviations were calculated for continuous variables. Frequencies and percentages were calculated for categorical variables. Scapular dyskinesis, cysts, retraction and migration were categorized as present or absent, and tear size as small or large, tear extension as involving one or more tendons, and atrophy as absent, moderate or severe. Group differences among discrete variables were evaluated using Mann-Whitney U-test or Kruskal-Wallis test. Group differences for continuous variables were evaluated using Spearman test. All tests were evaluated using two-sided hypothesis testing with statistical significance set to $\alpha = 0.05$. Calculations were performed using PASW version 18 (formerly SPSS Software, Chicago, IL).

RESULTS

Question 1

There was a weak association between WORC scores (average ± minimum-maximum, 26.5 ± 8.9-100) and 9PEG (average ± minimum-maximum, 20.9 ± 15-28), which was not statistically significant (*r*: 0.299, *P*: 0.076) [Table 2].

Question 2

The correlation of parameters pertaining to WORC and 9PEG is listed in Table 3.

A statistically significant, negative relationship was found between 9PEG and ROM in supination (*r*: −0.345, *P*: 0.034), as well as muscle strength of shoulder extensors (*r*: −0.399, *P*: 0.017), abductors (*r*: −0.404, *P*: 0.016), internal (*r*: −0.348, *P*: 0.04) and external rotators (*r*: −0.378, *P*: 0.025). There was also a statistically significant negative relationship between WORC scores and night pain/pain with package carrying (*r*: −0.362, *P*: 0.028). We found no significant relationship between WORC scores and ROM or muscle strength.

In addition, there was no statistical difference between WORC scores and 9PEG with regards to the presence of scapular dyskinesis, humeral head cysts, humeral head migration, tendon retraction, the number of tendons involved in RCT and the degree of atrophy ($P > 0.05$) [Tables 4 and 5].

DISCUSSION

In this study, we aimed to investigate whether two different validated tests (WORC, a self-reported outcome measure

Table 2: Correlation between WORC and 9PEG

WORC			9PEG			*P*	*r*
Mean ± SD	Median	Minimum-maximum	Mean ± SD	Median	Minimum-maximum		
42.52±30.95	26.52	8.92-100	20.99±2.81	21.12	17-28	0.076	0.299

SD = Standard deviation; WORC = Western Ontario Rotator Cuff Index; 9PEG = 9 Hole Peg Test

Table 3: Correlations between self-reported function and pain, ROM, muscle strength

Self-reported function	WORC		9PEG	
	r	*P*	*r*	*P*
ROM				
Elevation	−0.163	0.493	−0.342	0.14
Flexion	−0.138	0.409	−0.122	0.466
Extension	0.231	0.162	−0.011	0.946
Abduction	−0.027	0.87	0.038	0.82
Horizontal adduction	−0.015	0.931	−0.016	0.927
External rotation	−0.118	0.479	0.001	0.994
Internal rotation	−0.154	0.357	−0.004	0.981
Elbow extension	0.036	0.832	0.093	0.58
Elbow flexion	−0.162	0.33	−0.247	0.135
Supination	−0.185	0.265	−0.345	0.034*
Pronation	0.042	0.801	−0.036	0.83
Strength				
Flexor	0.249	0.137	−0.209	0.227
Extensor	0.255	0.128	−0.399	0.017*
Abductor	0.159	0.348	−0.404	0.016*
Adductor	0.268	0.229	0.184	0.425
Internal rotator	0.047	0.78	−0.348	0.040*
External rotator	0.116	0.495	−0.378	0.025*
Full can	0.212	0.207	−0.27	0.117
Elbow flexor	0.107	0.53	−0.338	0.047*
Elbow extensor	0.206	0.216	−0.253	0.137
Grab	0.026	0.875	−0.222	0.193
Triple pinch	0.107	0.528	−0.341	0.039*
Lateral pinch	0.309	0.063	−0.203	0.228
Pain				
At night	−0.348	0.035	0.061	0.72
Package carrying	−0.362	0.028*	0.076	0.653
↑90° abduction	−0.069	0.685	0.132	0.438
At rest	−0.292	0.08	−0.208	0.217
Dyskinesis	0.252	0.16	0.037	0.843

*Statistically significant association ($P < 0.05$); WORC = Western Ontario Rotator Cuff Index; 9PEG = 9 Hole Peg Test; ROM = Range of motion

versus 9PEG, a functional test) used in the evaluation of patients with RCT may be used interchangeably to determine the upper extremity function. The relationship between the two tests and the parameters that may potentially influence the outcomes was also investigated. We found that, as outcome measures with distinct parameters, WORC and 9PEG yield different results with regards to the upper extremity function in patients with RCT.

We acknowledge that our study has some limitations that influenced the overall results. The relatively small sample size constituted by a majority of patients with small-sized RCT is the major drawback of this study. The use of a single outcome tool (WORC) for determining the upper extremity function is another limitation that precluded the comparison of a possible relationship between 9PEG and other outcome tools. Further studies with larger patient groups, which utilize multiple outcome tools and tests are warranted to conclude on the relationship and effectiveness of these tools in determining the upper extremity function.

It has been shown that validated, self-reported, condition-specific outcome measures are predictable and accurate in determining the extremity function and the response to treatment in musculoskeletal conditions, and are therefore recommended for utilization in patient populations with this group of disorders,[25] such as the use of WORC in patients with RCT and the use of Western Ontario Osteoarthritis of the Shoulder Index in patients with glenohumeral osteoarthritis.[26] On the other hand, it has been proposed that in addition to the objective measurements such as ROM and muscle strength, the utilization of performance-based tests prove more effective in determining subtle functional losses when compared with the subjective methods.[5] Thus, we used WORC to determine the upper extremity function in the setting of RCT, and used 9PEG to evaluate the functional performance in this study.[7,21]

Question 1

One of the main findings of this study is the weak association between WORC scores and 9PEG, which was not statistically significant. This weak association and the difference between the parameters related to each method suggest that the use of one method as an alternative to the other one is not appropriate. In this study, considering $\alpha = 0.05$ (two-sided) and $\beta = 0.10$ (power = 90%); the number of patients needed to meet assumption were 36. To the authors' knowledge, there exists no study in the literature investigating the accordance of a self-reported outcome measure with 9PEG for determining the upper extremity function in patients with RCT. Nevertheless, a weak relationship has been shown between objective measurements such as ROM and muscle strength, and subjective scores of SPADI and UPenn Shoulder Scale in patients following rotator cuff repair.[5] Another study has shown that no association exists between FIT-HaNSA and WORC for determining the upper extremity function in healthy shoulders.[10]

Another notable finding of this study is the negative relationship found between 9PEG scores and ROM in supination. However no association was noted between 9PEG scores and shoulder ROM. It has been previously shown that active abduction is the main factor that determines WORC scores in patients with RCT.[27] In this regard, it is not surprising to find no relationship between 9PEG and shoulder ROM in our study population, because 9PEG is a performance-based test that is routinely performed under the shoulder level (90°< abduction). Most of the activities related to the shoulder joint are performed in the scapular plane, rather than the frontal plane. We think that the shoulder joint is placed in a favorable position in the scapular plane during 9PEG, which provides an advantage in performing the test and may interfere with the performance-based results of the test. In addition, the fact that 9PEG is performed under the shoulder level creates a disadvantage in determining the functional loss secondary to the pain elicited by overhead activity (90°< abduction).

Table 4: Comparison of clinical symptoms

Scapular dyskinesis	Dyskinesis (+) *n* = 20		Dyskinesis (–) *n* = 14		*P*
	Median	Minimum-maximum	Median	Minimum-maximum	
WORC	70	23-100	49	13-100	0.14
9PEG	21	18-28	19	17-26	0.67
Humeral head cysts	**Present *n* = 24**		**Absent *n* = 14**		
WORC	92	90-100	93	90-100	0.693
9PEG	22	17-26	20	15-28	0.397
Migration	**Migration (+) *n* = 30**		**Migration (–) *n* = 8**		
WORC	92	91-100	93	90-100	0.835
9PEG	23	20-26	20	15-28	0.132
Retraction	**Retraction (+) *n* = 22**		**Retraction (–) *n* = 15**		
WORC	67	13-100	53	20-100	0.329
9PEG	19	15-26	22	17-26	0.072
Number of tendons in tear	**Single tendon *n* = 29**		**2-4 tendons *n* = 8**		
WORC	63	13-100	51	24-100	0.957
9PEG	21	15-28	23	17-26	0.197
Tear size	**Small *n* = 25**		**Large *n* = 13**		
WORC	65	13-100	53	20-100	0.686
9PEG	21	15-28	22	17-26	0.185

WORC = Western Ontario Rotator Cuff Index; 9PEG = 9 Hole Peg Test

Table 5: Comparison of scores according to the degree of atrophy

Atrophy	Normal muscle (*n* = 11)		Subtle fatty changes (*n* = 22)		Advanced fatty changes (*n* = 5)		*P*
	Median	Minimum-maximum	Median	Minimum-maximum	Median	Minimum-maximum	
WORC	92	90-94	93	90-100	93	91-100	0.57
9PEG	19	17-27	21	15-26	22	20-26	0.07

WORC = Western Ontario Rotator Cuff Index; 9PEG = 9 Hole Peg Test

Question 2

We found that 9PEG test performance displayed a positive trend parallel to the increases in shoulder extensor, internal and external rotators and abductors, as well as elbow flexors and triple grab strength, while there was no significant relationship between WORC scores and the upper extremity ROM measurements, as well as the muscle strength. It has been shown that the elevation and abduction strength are the factors that determine WORC scores in patients with RCT.[27] On the contrary, it has been reported that internal and external rotation strength do not have a direct relationship with the upper extremity functional performance (FIT-HaNSA) or WORC scores in healthy shoulders.[10,28] These results suggest that WORC and 9PEG are distinct outcome measures with different methodology in determining the upper extremity function, and the effectiveness of WORC in determining the upper extremity functional losses may be limited in comparison with 9PEG, particularly in the setting of strength loss. Further studies with larger groups are warranted to conclude on this matter.

We noted that WORC scores decreased as the night pain and pain with package carrying increased; however, we found no relationship between WORC scores and pain at rest, as well as pain with activities over 90° of elevation. With regards to the pain, not being able to sleep due to night pain and functional loss in daily life secondary to pain were the most pronounced complaints of our patient group. From this aspect, the results of our study are in accordance with patients' complaints. Recent findings suggest that there is no relationship between WORC scores and pain at rest,[27] which is parallel to our findings. The fact that there was no relationship between WORC scores and pain at rest, as opposed to night pain and pain with package carrying, may be attributed to patients' decreased quality of life caused by sleeplessness and intense night pain overshadowing their relatively less severe pain at rest. The education level of patients may have also influenced the results since it has been shown that WORC scores are affected by educational level. Seventeen of our patients were primary school graduates (44%) and 3 were illiterate patients (7.9%). A recent study pointed out that university graduates have 17.4 more points of WORC score in average as compared to the primary school graduates and illiterate individuals.[27] Previous studies comparing the psychometric features of these measures have reported on high standard errors,[5] thus we believe our patients may have had difficulties in making decisions, while scoring their pain.

Scapular dyskinesis may result either from a structural biomechanical disorder or pain caused by the tear.[24] The presence of RCT affects the glenohumeral force vectors, and this may cause dynamic instability in upper extremity during shoulder elevation and depression. The presence of scapular dyskinesis has been reported to decrease WORC scores by 6.85 points.[27] In contrast, the presence of scapular dyskinesis had no significant effect on WORC or 9PEG scores in our study.

Similarly, neither the presence of humeral head cysts, migration and tear retraction nor the degree of fatty atrophy had any negative influence on the outcomes of WORC or 9PEG. In spite of surgical intervention, fatty degeneration and muscle atrophy are irreversible in the setting of chronic RCT.[28,29] The presence of fatty degeneration causes recurrent tears and deterioration of clinical symptoms.[30,31] The atrophy of the supraspinatus and infraspinatus muscles has been reported to decrease the WORC scores by 4.21 and 7.37, respectively.[27] It has been shown that the tear size is not a factor that determines the upper extremity function (WORC) in symptomatic, atraumatic RCT.[27] However, following the surgical repair, the tear size has been shown to influence the function in previous studies with self-reported questionnaires and clinical evaluations.[25,32-34] Particularly, after repair of large and massive sized tears, functional outcomes such as muscle strength and objective active ROM measurements have been found to be inferior in short,[33] mid[32,34] and long-term follow-ups.[18] The relationship between the tear size and functional outcomes has been varying following arthroscopic repair. Some authors propose that the functional outcome is not influenced by the tear size or muscle atrophy, while the others advocate that the integrity of rotator cuff is directly related to the functional outcome.[24,35,36] More studies that objectively evaluate the upper extremity function are required to address this controversy.

We acknowledge that our study has some limitations that influenced the overall results. The relatively small sample size constituted by a majority of patients with small-sized RCT is the major drawback of this study. The use of a single outcome tool (WORC) for determining the upper extremity function is another limitation that precluded the comparison of a possible relationship between 9PEG and other outcome tools. On the other hand, interpreting of the questions in survey (WORC) of patients with basic schooling may differ in patients with university graduates. In this regard difference in education, levels may affect the results and may constitute a limitation for the study. Further studies with larger patient groups which utilize multiple outcome tools and tests are warranted to conclude on the relationship and effectiveness of these tools in determining the upper extremity function.

CONCLUSIONS

The weak association between WORC and 9PEG, and the difference between the parameters related to each method suggest that they should not be used interchangeably to determine the upper extremity function. We recommend the utilization of 9PEG instead of WORC for upper extremity functional assessment in the setting of loss of muscle strength.

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