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Original Article

The Shoulder Functional Performance and Its Impacted Factors After Arthroscopic Rotator Cuff Repair: A Comparative Study with Healthy Controls

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ABSTRACT

Objective: The aims of this study were (a) to compare shoulder functional performance, shoulder functionality, grip strength, and scapular endurance between individuals with rotator cuff repair (RCr) and healthy controls, and (b) to investigate the impact of these factors on shoulder performance.

Methods: In this study, a study group (n = 32) of individuals with RCr and a control group (n = 32) of healthy individuals were included. The study group comprised individuals who underwent surgical repair for full-thickness rotator cuff (RC) ruptures (excluding massive size) and completed at least 24 weeks of postoperative follow-up. Shoulder performance and functionality, grip strength, and scapular endurance were evaluated by the Functional Impairment Test-Hand-andNeck/Shoulder/Arm (FIT-HaNSA), the Modified Constant–Murley Score (MCMS), the Jamar hand dynamometer, and the Scapular Muscle Endurance Test, respectively. These factors affecting the performance of the shoulder were examined by regression analysis.

Results: Functional Impairment Test-Head and Neck, Shoulder, Arm, the MCMS, and the Jamar score were lower in the study group ($P < .05$). Scapular endurance was similar in both groups ($P > .05$). Functional Impairment Test-Head and Neck, Shoulder, Arm was correlated with the MCMS, the Jamar score, and the scapular endurance, respectively (r: 0.455 / 0.727 / 0.438; $P < .05$). A regression analysis was run to determine the variables affecting shoulder performance. The values of pain, strength, total score of MCMS, scapular endurance, and Jamar score explained 14.8%, 29.5%, 27.3%, 18.9%, and 30.8% of shoulder performance, respectively ($P < .05$).

Conclusion: The functional performance of the shoulder was lower in individuals with RCr compared to healthy individuals. The most significant variables affecting shoulder performance were upper limb strength, shoulder functionality, scapular muscle endurance, and the pain sub-parameter of MCMS, according to the rates of influence, respectively.

Keywords: Function, performance, rotator cuff, shoulder, strength, endurance

Introduction

Full-thickness rotator cuff (RC) rupture is a common and debilitating shoulder condition characterized by a complete tear in the tendon fibers. This injury has been reported in nearly 50% of the overall population older than 60 years.[1] Rotator cuff ruptures could bring about a number of symptoms, such as shoulder pain, muscle weakness, the inability to do tasks that require reaching overhead, and loss of function and movement.[2]

Individuals suffering from RC rupture encounter challenges in performing daily activities, particularly tasks involving repetitive shoulder elevation, as a result of diminished strength and imbalances within the RC muscle group.[3] The RC muscles play a vital role in maintaining equilibrium during coordinated movements of the glenohumeral joint. Additionally, insufficient scapular stabilization, chronic pain, and decreased muscle strength in individuals with RC rupture can impede the shoulder's ability to provide proximal control and accomplish essential activities in daily life.[4,5]

Arthroscopic techniques, particularly the double-row suture technique, are widely recognized and prominent approaches in the treatment of a majority of full-thickness RC ruptures.[6] Following RC repair, individuals commonly experience a reduction in range of motion (ROM), increased pain, and compromised shoulder function during the acute phase of recovery. However, numerous studies demonstrate that these symptoms tend

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to gradually improve over a more extended period, typically spanning at least 6 months.[7,8] Kurowicki et al[8] examined the data of 627 patients who underwent RC repair and reported significant improvements of up to 90% in terms of pain and functionality at 6 months.

In the long term, ranging from 6 to 24 months after surgery, changes in shoulder function have often been observed through sport-specific performance, muscle performance, and self-reported surveys.[7-9] However, it is known that 93% of individuals with RC ruptures experience difficulties in performing repetitive activities commonly used in daily life, such as reaching shelves, raising their arms overhead, and carrying objects.[1] Therefore, evaluating the functional performance of the shoulder using a test battery that simulates daily life activities and includes repetitive tasks after RC repair can provide more specific results from a clinical perspective. Surprisingly, there is scant evidence on the functional performance of the shoulder in the period when full participation in activities of daily living is expected after surgery.

On the other hand, individuals with RC ruptures may experience adverse effects on biomechanical factors related to shoulder functionality, such as muscle strength and scapular endurance, when compared to healthy individuals.[2,3] However, there is a lack of clear understanding in the literature regarding how these factors are specifically affected in the long term when individuals are expected to regain their ability to perform daily life activities after surgery.

Therefore, the aims of this study were (a) to compare shoulder functional performance and functionality, grip strength, and scapular endurance between individuals with arthroscopic RC repair and healthy controls and (b) to investigate the effect of these factors on shoulder functional performance.

Methods

Study Design

This cross-sectional observational study was approved by Abant Izzet Baysal University Clinical Research Ethics Committee (No. 2018/104) in line with the 1964 Declaration of Helsinki. This study was part of the clinical trials (www.ClinicalTrials.gov NCT04388306). Both written and verbal consent were obtained from all subjects.

Participants

The sample size was determined using GPower 3.1 software (FranzFaul, UniversitatKiel, Germany),[10] based on the rationale of the difference in the Functional Impairment Test-Head and Neck, Shoulder, Arm (FIT-HaNSA) between groups (shoulder disability patients and controls) (alpha 0.05, power 0.8, and medium effect size 0.5) using a 2-tailed test for independent samples.[11] The sample size was identified as at least 26 participants per group. Considering the possibility of data loss (participants' inability to complete performance activities, etc.), the sample size for each group was increased by 20%, resulting in a total of 64 participants, with 32 individuals in each group.[12]

Patients who underwent arthroscopic RC repair (the study group) at the Abant Izzet Baysal University, Department of Orthopedics and Traumatology, and healthy controls were included in this study. The study group sample consisted of individuals who underwent RC repair for full-thickness RC ruptures (except the massive ones) with magnetic resonance image documented and had completed at least 24 weeks of postoperative follow-up. A convenience sample of healthy individuals (from relatives of individuals with RC repair and university/hospital staff) was recruited as a control group.

The age range was determined to 40-65 years old for both groups. Individuals who underwent the same RC surgical procedure (acromioplasty and/or tenodesis with arthroscopic RC repair) on the dominant side extremity, who had undergone rehabilitation in the postoperative period, and who performed 90° and above active shoulder elevation movement were included in the study. In the control group, individuals who had no experience of neck and back pain in the last year and who had the negative Full Can and the Jobe test were included. Individuals with a history of other pathologies of the upper extremity and with recurrences that require reoperation, in addition to any disease condition (such as a neurological and/or vestibular disease) that makes it impossible to perform the test, were excluded from the study.

The surgical interventions of all patients were conducted by a skilled and experienced surgeon under standardized surgical conditions.

Surgical Procedure

The patient was positioned in the appropriate lateral decubitus position. Both knees are bent, and padding in the form of a pillow is placed under the down knee and in between the knees to avoid pressure injuries to the common peroneal nerve. An axillary roll is placed under the nonoperative axilla. After positioning, lateral traction is applied.

The posterior portal was positioned 2 cm inferior and 1 cm medial to the posterolateral corner of the acromion. The anterior portal was established under arthroscopic visualization from the posterior portal. A spinal needle is inserted from the soft spot, and the cannula is directed into the anterior triangle formed by the labrum, biceps tendon, and subscapularis. Subsequently, the scope is placed in the subacromial space, and 2 lateral portals, located 1-2 cm distal to the lateral edge of the acromion, are established. The size, shape, and retraction of the rotator cuff tears are determined, and the tendon footprints are debrided. A double-row repair was performed for all tears. Subacromial decompression was performed following the completion of the cuff repair. Extraarticular tenodesis was performed for degenerative tendon pathologies of the long head of the biceps tendon in patients younger than 50 years. A Tenotomy was performed on patients after 50 years of age.

This study is a cross-sectional study that only evaluates postoperative data. Due to the study design, which exclusively concentrates on postoperative evaluations, blinding and randomization procedures were not incorporated.

Outcome Measures

The sociodemographic and physical characteristics of the participants were recorded. To eliminate the fatigue factor, 5-minute breaks were given after each test.

Functional Impairment Test-Head and Neck, Shoulder, Arm

Functional Impairment Test-Head and Neck, Shoulder, Arm (FIT-HaNSA) is a test battery that consists of 3 tasks simulating overhead work and lifting activities, and it evaluates the shoulder functional performance. Its reliability and validity in shoulder pathologies were performed by Kumta et al.[13] The test material used in this study was constructed using steel and wooden materials in accordance with the examples in the literature.[11,14]

The first task represents reaching and lifting activities at waist level, while the second task is based on activities at eye level. In the first task, the shelf was placed at the waist level of the participant and 25 cm above the first one. In the second task, the shelf height was adjusted to the participants' eye level and 25 cm below it. In both tasks, 3 jars weighing 1 kg each were placed on the lower shelf. The speed of movement was standardized by means of a metronome with 60 beats per minute. Then all the jars were moved up and down on shelves, respectively.[13]

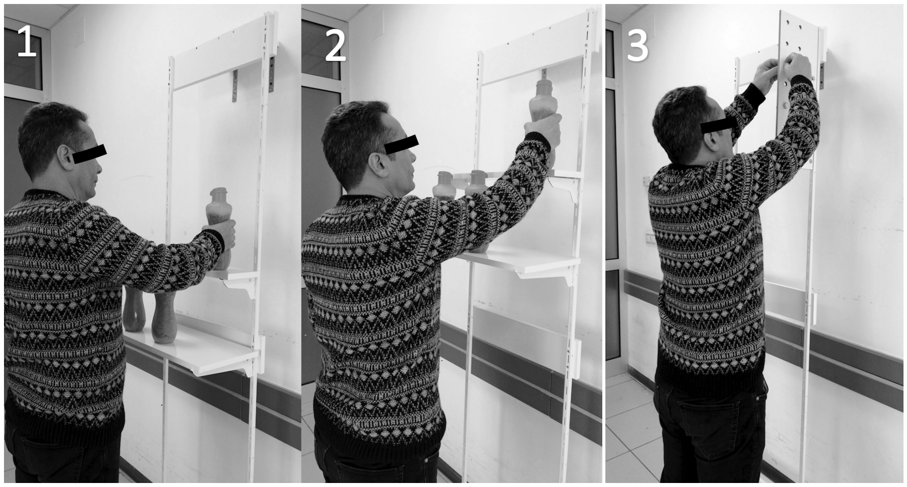

Figure 1. The FIT-HaNSA; Task 1, "Waist Level"; Task 2, "Eye Level"; Task 3, "Overhead Activity".

The third task is to perform sustainable overhead activities. A plate was placed vertically on the shelf at the eye level of the participant. The participant was instructed to use both arms continuously to screw and unscrew the bolts and to move them between the 3 holes in the connecting plate. Each task continued for a maximum of 300 seconds or until 1 of the stopping criteria was reached (Figure 1). The percentage of time for each task was calculated.[13] Averaging of the 3 tasks was recorded as a summary score.

Modified Constant Murley Score

Shoulder functionality was analyzed by using the Modified Constant–Murley Score (MCMS) to evaluate pain, daily living activities, ROM, and strength. High scores characterize quality shoulder function. The force in the shoulder abduction position was measured with the digital analyzer defined by the spring balance technique. When the test position could not be taken or severe pain occurred during the measurement, the test was terminated and scored 0 points.[15]

Scapular Muscle Endurance Test

The endurance of the serratus anterior and the trapezium muscles was evaluated with the scapular muscle endurance (SME) test. The individuals took a standing position with their shoulders and elbows flexed to 90°. A dynamometer with 1kg/10N resistance was given to the participant, and a wooden bar was placed between the participant's elbows to maintain the test position. The participant was asked to pull the dynamometer with both hands in this position. The test was terminated when the participant could not maintain 90° of shoulder flexion, the bar dropped, or the participant felt severe discomfort.[16,17] The results were recorded in seconds.

The Upper Extremity Muscle

Grip strength was evaluated with the Jamar hand dynamometer.[18] The test was performed by measuring both sides. Participants were seated with their shoulders adducted, their elbow flexed at 90°, and their forearm and wrist semipronated. Three trials with 15-20 seconds of rest were performed. The average score was recorded in kg/N.[18]

Statistical Analysis

All statistical analyses were performed using The Statistical Package for Social Sciences version 24.0 software (IBM Corp.; Armonk, NY, USA). The Kolmogorov–Smirnov test was used to assess the test of normality. The chi-square test was used for gender, and the independent *t*-test was used to analyze the difference between groups in height, weight, and body mass index parameters (the assumption of normality was met). The Mann–Whitney *U*-test was utilized to assess the differences in age, FIT-HaNSA, MCMS, SME, and grip strength between the groups. Besides that, a paired sample *t*-test was performed to compare the values of the grip strength between the right and left upper extremities of each group. The associations between the mean values of FIT-HaNSA, shoulder function, scapular endurance, and shoulder strength were analyzed by Spearman's correlation coefficient. The correlation was classified as strong (r ≥ 0.70), moderate (r ≥ 0.40 or r < 0.70), or weak (r < 0.40), adopting a 95% CI.[19] These factors affecting shoulder performance were examined by multiple regression analysis. Seven regression models were built to examine the effects of function, endurance, strength, and the sub-parameters relevant to these scales on shoulder performance separately. In the analyses, $P < .05$ was considered statistically significant.

Results

Sixty-four participants were included in this study. There was no significant difference between the 2 groups in terms of demographic information or medical history (Table 1). The age of participants ranged

Table 1. The Sociodemographic Information and Medical History Parameters of Groups

	Study Group (n = 32) Mean ± SD	Control Group (n = 32) Mean ± SD	$P^{‡}$
Age (y)	55.25 ± 5.9	52.44 ± 7.06	.09
Height (m)	1.58 ± 0.09	1.65 ± 0.08	.008*
Mass (kg)	80 ±9.77	75.86 ± 13.64	.168
BMI (kg/m²)	29.02 ± 4.27	27.97 ± 4.29	.09
Sex			
Females	20	13	.08
Males	12	19	
Dominant side (n)			
Right	31	32	
Left	1	0	
Post-surgical rehabilitation (n)			
No	0	-	
Yes	32	-	
Post-op period (week)	38.56 ± 15.22	-	

BMI, Body mass index.

‡Chi-square test (gender) and the independent *t*-test.

*$P < .05$ statistically significant.

Table 2. Comparison of Shoulder Functional Performance, Shoulder Functionality, Total Upper Extremity Muscle Strength, Scapular Endurance Values of Participants

	Study Group (n = 32)		Control Group (n = 32)		
	Mean ± SD	**Mean (Minimum-Maximum)**	**Mean ± SD**	**Mean (Minimum-Maximum)**	***P*‡**
FIT-HaNSA (%)					
Task 1	62.7 ± 33.94	58.17 (16.33-100)	96.49 ± 12.49	100 (37.67-100)	<0.001
Task 2	39.76 ± 27.18	27.67 (14.67-100)	77.58 ± 28.88	100 (17.67-100)	<0.001
Task 3	58.02 ± 25	51 (26.67-100)	84.03 ± 26.27	100 (16.67-100)	<0.001
Summary score	53.49 ± 25.06	44.83 (25.56-100)	86.03 ± 15.66	90.39 (50-100)	<0.001
MCMS					
Pain	11.53 ± 3.56	12 (5-15)	14.75 ± 1.02	15 (10-15)	<0.001
Daily life activity	15.53 ± 4.21	18 (7-20)	20 ± 0	20 (20-20)	<0.001
Movement	30.94 ± 7.9	34 (12-40)	37.69 ± 2.33	38 (32-40)	<0.001
Strength	9.65 ± 4.42	8.8 (1.2-21.9)	16.78 ± 6.21	17.6 (5-35)	<0.001
Total score	67.65 ± 13.29	67.75 (47.4-90.9)	89.21 ±6.52	89.9 (74-100)	<0.001
Grip strength (kg/N)					
Dominant side	28.63 ± 8.44	25.75 (17-53)	36.53 ± 8.11	37.55 (21.3-56.3)	<0.001
Non-dominant side	28.27 ± 7.78	26.3 (16.5-49.5)	34.53 ± 8.67	34.8 (17.6-57)	0.003*
Between groups (*P*)§	0.542		0.002*		
Scapular Endurance (sec)	30.79 ± 38.28	17 (0-185)	44.47 ± 35.28	39.5 (0-113)	0.087

FIT-HaNSA, Functional Impairment Test-Hand and Neck/Shoulder/Arm. MCMS, Modified Constant Murley Score.
**P* < .05 statistically significant.

from 45 to 61 years (mean age 53.8 ± 6.4 years). In addition, individuals had a mean of 38.56 ± 15.32 weeks in the postoperative period.

All tasks and summary scores of FIT-HaNSA were significantly lower in the study group compared to controls (*P* < .05) The total score of MCMS, pain, daily living activities, ROM, and strength (all sub-parameters of MCMS) were lower in the study group than the controls (*P* < .05) (Table 2).

While there was no statistically significant difference in the Jamar scores between the dominant (28.63 ± 8.44 kg/N) and non-dominant sides (28.27 ± 7.78 kg/N) in the study group, those scores on both sides were lower compared to the control group (Table 2).

Table 3 shows a strong correlation between the FIT-HaNSA and strength. FIT-HaNSA also showed a positive, moderate correlation with the total score of MCMS, scapular endurance, and Jamar score.

A regression analysis was run to determine the variables affecting shoulder performance. The effect of pain, strength, total score of MCMS, scapular endurance, and the dominant side Jamar score on FIT-HaNSA was significant and positive in the study group (*P* < .05). On the contrary, no effect of any variable was observed on the functional performance of the shoulder in the control group. In addition, the values of pain, strength, total score of MCMS, scapular endurance, and Jamar score explained 14.8%, 29.5%, 27.3%, 18.9%, and 30.8% of shoulder performance, respectively (Table 4).

In this study, conducted with 64 people, post hoc power analysis was performed. The effect size value of the study was calculated as 1.32 (Cohen's d) based on the results of the FIT-HaNSA, and the post-hoc power of this study was calculated as 0.99 (1-β) with an alfa of error of 0.05.

Table 3. Factors Associated with Functional Performance of Shoulder

	FIT-HaNSA (summary score)			
	Study Group (n = 32)		**Control Group (n = 32)**	
Variables	*P*‡	test value (*r*)§	*P*‡	test value (*r*)§
MCMS				
Pain	.071	0.323	.456	-0.136
Daily life activity	.082	0.312	-	-
Movement	.359	0.168	.262	0.204
Strength	<.001	0.673	.234	0.217
Total score	.009*	0.455	.293	0.192
Grip strength (kg/N)				
Dominant side	<.001	0.727	-	-
Scapular endurance (sec)	.02*	0.438	.22	0.223

FIT-HaNSA, Functional impairment test-hand and neck/shoulder/arm; MCMS, Modified Constant–Murley Score.
‡Spearman correlation analysis.
§Spearman Correlation coefficients (r).
**P* < .05 statistically significant.

Discussion

This cross-sectional study showed that shoulder functional performance, which requires complex movements of the shoulder and muscle strength, was weak in individuals who completed the 6-months RC repair. The most significant variables affecting shoulder performance were upper limb strength, shoulder functionality, scapular muscle endurance, and the pain sub-parameter of MCMS, according to the rates of influence, respectively.

A study conducted by Alizadehkhaiyata et al[11] reported that patients with subacromial impingement syndrome experienced more discomfort in the first task of FIT-HaNSA than in the second task. For participants with RC repair, the average activity performed at eye-level (39.76%) of FIT-HaNSA was lower than that at waist level (62.7%) in this study. Its probable reason was that the RC and deltoid muscles, weak during lifting and lowering activities at eye level, are exposed to higher loads than at waist level. Besides that, eye level activities require the individual to raise the shoulder above the shoulder line, using the supraspinatus as the main muscle, which tends to be the most affected in RC repair.[20] Poor scapular muscle stabilization and insufficient grip strength required for shoulder elevation above 90° may have adversely affected the proximal stability of the shoulder joint at eye level. Looking at the scapular kinematics, the loads on the glenohumeral joint increase, and the acromiohumeral distance considerably narrows down at 60° abduction of the shoulder. Additionally, the subacromial

Table 4. Factors Affecting Functional Performance of Shoulder

	Study Group (n = 32)			Control Group (n = 32)		
	$R^{2§}$	$P^‡$	β Standardized Coefficient (95% CI)[†]	$R^{2§}$	$P^‡$	β Standardized Coefficient (95% CI)[†]
MCMS						
Pain	0.148	.035*	361 (0.156-5.211)	0.109	.057	371 (0.172-5.054)
Daily life activity	0.075	.13	273 (−0.509-3.76)	-	-	-
Movement	0.013	.440	141 (−1.529-3.425)	0.004	.355	169 (−0.630-1.701)
Strength	0.295	<.001	256 (0.264-3.429)	0.065	.158	256 (−.264-1.553)
Total score	0.273	.002*	−.523 (.387-1.585)	0.489	<.001	(−.222-1.503)
Grip strength (kg/N)	0.308	<.001	300 (0.018-1.266)	0.09	.256	3 (0.108-1.266)
Scapular endurance (sec)	0.189	.009*	.207 (0.070-0.254)	0.043	.096	(−0.07)-0.254)

Cl, Confidence interval. DS, Dominant Side; MCMS, Modified Constant Murley Score.
[§]Values of regression model.
[‡]Multiple linear regression analysis.
[†]95% confidence interval.
*$P < .05$ statistically significant.

space expands with the upward rotational movement of the scapula during shoulder elevation between 120° and 180°.[4] In the FIT-HaNSA test, it is clear that shoulder elevations at 60° and 120°-180° degrees are required for the activities at eye-level and overhead-level, respectively.[13] Consequently, the high percentage of performance and the overhead activity tolerability could be the results of the release of pressure on the RC tendons. The decrease in the performance percentage of the third task can be attributed to its relatively static position, which demands greater stability from the scapular muscles compared to the other tasks.[13] Additionally, the lack of familiarity with this specific task may also contribute to the observed decrease in performance.[17] We suggest that performance-based lifting and reaching activities similar to the FIT-HaNSA test may be emphasized to achieve gains that will facilitate daily functional activities after surgery.

Several studies on shoulder functionality after surgery have emphasized that significant functional recovery with anatomic restoration is expected in the long term after RC repair.[21,22] Studies with long-term follow-up after RC surgery have reported that shoulder functionality increases up to 12 months postoperatively and then reaches a plateau phase. In addition, it was reported that ROM and strength parameters improved after 6 months.[21,23,24] The decrease in isometric shoulder strength, pain experienced during end-range movements and weightlifting activities, and avoidance of daily activities could potentially have an adverse effect on shoulder functionality among the participants. Considering the post-op period, the total MCMS, pain, daily activities, ROM, and strength of participants with RC surgery were lower than those of healthy participants, which supports the literature.

Horsley et al[25] reported that a strong correlation between grip strength and RC strength was observed in all positions for both the left and right hands. However, Manske et al[18] interestingly reported that there was no relationship between grip strength and RC dysfunction in individuals with rotator cuff tears. Despite the conflicting results regarding the relationship between grip strength and shoulder strength, as stated by Horsley et al[25], it is possible that grip strength has decreased due to the redistribution of force in the RC muscles following an injury. Because the simultaneous activation of proximal and distal arm muscles is required during gripping, this may have led to the individual's inability to perform activities of daily living such as grasping objects of different weights.[18] Future studies can focus on investigating the relationship between grip strength and rotator cuff muscle, function specifically after rotator cuff surgery, to address this confusion.

The muscle strength of the non-dominant side of the individuals with RC was significantly lower than that of the control group. This difference may be due to decreased activity of individuals after surgery and avoidance of activity to protect the painful area. In addition, since upper extremity movements, especially overhead activities, may require bilateral extremity synergistic performance, this may be a reason for the presence of lower muscle strength compared to healthy individuals after surgery.[26] Therefore, bilateral extremities should be evaluated in the evaluation of muscle strength in individuals with RC in prospective studies.

Many studies have presented that RC ruptures cause scapular muscle weakness and insufficient scapular stabilization.[5] Atta et al[27] stated that the scapular endurance of participants with shoulder pain was lower than that of healthy controls. However, the results of the present study did not support the notion of low scapular endurance in shoulder pathologies. In the study of Atta et al[27] while the effect of scapular endurance was investigated on patients with existing pathological status, our study was conducted on patients with tendon integrity with surgical intervention. This result might be associated with the disappearance of the tendon rupture pathology.

Hawkes et al[28] measured the EMG activity of 13 muscles around the shoulder via FIT-HaNSA to examine the dynamic activity of the muscles during upper limb function. They emphasized that the deltoid, teres major, latissimus dorsi, and RC muscles showed high activation for glenohumeral movement and stability.[28] For active shoulder elevation in FIT-HaNSA tasks, deltoid and RC muscles need to be synchronized and coordinated, as stated by Hawkes et al[28] Considering the key role of muscles for mobility and function, these results explained the positive effect on shoulder performance with the increase of grip strength, scapular endurance, and shoulder functionality. Uddin et al[14] demonstrated that pain threshold and low tolerance had a negative effect on the functional performance of the patients with shoulder pain, and isolated pain explained 34% of the functional performance score. This study, compatible with the study of Uddin et al,[14] found that the presence of pain had a negative effect on shoulder functional performance. In addition, it was seen that the rate of pain has the lowest rate of 13.7% among the parameters affecting functional performance. In our opinion, the low rate of effect was related to the fact that the participants received an early post-op physiotherapy and rehabilitation program and were evaluated at the post-op 24th week, when the pain was largely tolerable.

This study has some limitations. The deficiency of a group that included individuals with non-surgical rotator cuff tears is 1 of the main limitations of this study. It was not sufficient, thus, to determine whether the factors predisposing to rupture occur after RC repair or are the continuation of the already existing disorder. The control group consisted of completely healthy participants. Although it is known that surgery is an effective treatment method for RC ruptures, the effectiveness of surgery could not be demonstrated in this study. Secondly, the evaluation period could not be divided into certain time intervals, such as 3-6 months and 6-12 months. The number of participants was not sufficient for such a distinction. Lastly, this study could not provide gender-specific data to examine the parameters affecting shoulder performance. Understanding the impact of gender on data related to shoulder performance is of clinical significance in future studies.

Conclusion

In conclusion, this study demonstrated that shoulder functionality, scapular muscle endurance, and grip strength might be developed for improved shoulder performance. Including performance training that simulates daily activities in the rehabilitation program applied after surgical treatment might support the optimal recovery of individuals. To provide clinicians with a clear understanding of upper extremity functional abilities, we recommend that individuals with RC repair be evaluated with measurement tools that include a combination of strength, function, and performance.

Ethics Committee Approval: Ethical committee approval was received from the clinical Research Ethics Committee of Bolu Abant İzzet Baysal University (Approval no: 2018/104, Date: May 24, 2018).

Informed Consent: Written and verbal informed consent was obtained from the participants who agreed to take part in the study.

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