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Early versus delayed rehabilitation protocol after arthroscopic rotator cuff repair

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***Abstract*---**Objective: To assess the effect of immobilization versus early range of motion exercises in treating primary arthroscopic rotator cuff repair secondary to full-thickness tear. Design: Parallel group randomized clinical trial. Participants: 30 patients with primary arthroscopic rotator cuff repair secondary to full-thickness tear participated in the study. Interventions: Patients were divided into two groups, 15 in each group. The first group (A) received early range of motion (ROM) exercises started 2 weeks post-operative; and the second group (B) immobilized immediately post operative and received delayed range of motion exercises started 6 weeks post-operative. Main outcomes: Shoulder pain and function were assessed by shoulder pain and disability index (SPADI). ROM of shoulder flexion, abduction, and internal rotation were assessed by standard goniometer. Scapular protraction was assessed by digital caliper and scapular upward rotation was assessed by bubble inclinometer. All outcomes were assessed in both groups 6 weeks, 3 months and 6 months postoperative. Results: A significant increase in flexion,

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abduction and internal rotation ROM at 6 weeks, 3 months and 6 months was observed between groups in favor of Group A. Furthermore, significant decrease in scapular protraction in Group A, while no significant difference in scapular upward rotation at 3 months and 6 months were observed. The shoulder function was improved in both groups with no significant differences except for 6 weeks in favor of Group A. Conclusion: Our results suggest that early passive ROM exercises are recommended, because the shoulder ROM were better at all follow-up periods without compromising tendon integrity. On the other hand, it may be effective for short term improvement in shoulder pain and function.

***Keywords*---**rotator cuff tears, ROM, immobilization, arthroscopic repairs.

Introduction

Rotator cuff tears (RCT) are the most common cause of shoulder pain and dysfunction. Its incidence is about 13% in those over the age of 50 and greater than 50% in people over the age of 80 (1,2). Patients with small incomplete RCT usually get better with conservative non-operative therapy and rarely proceed to surgical repair. Surgical repair of the rotator cuff is indicated when conservative therapy failed to protect tear or relief symptoms. One of the major challenges in surgical repair is tendon-to-bone healing variability among personals. Therefore, recurrent tears following repair range from 16% in young participants for non-retracted tears to 94% in massive tears (3).

A period of mobility limitation is recommended after surgical rotator cuff repair; however, the best time for immobilization is uncertain. Patients are commonly asked to wear a sling for six weeks with activity limitation for the affected shoulder to allow proper healing (4). This time is crucial for protection the repaired tendon to allow proper healing and to prevent recurrent tear (5). Delay in motion, on the other hand, may increase the likelihood of postoperative shoulder stiffness, muscular atrophy, and delayed functional recovery (4).

Several clinical trials compared early versus delayed rehabilitation intervention for rotator cuff repair but there was conflicting evidence about the appropriate timing. The meta-analysis suggested that no additional benefit provided by early motion concerning the shoulder pain and function. On the other hand, it was beneficial for rapid return of joint motion although some studies found no differences between early and late rehabilitation protocols concerning shoulder ROM. Furthermore, tendon integrity was not differed between both early and delayed rehabilitation and number of retear was similar between groups. However, most of the randomized controlled trials (RCTs) included in the review had a high risk of bias and poor quality (6). It is difficult to make a clinical decision on the proper timing for the optimum rehabilitation program and the ideal time to begin postoperative rehabilitation based on the current evidence.

Therefore, the aim of the current study is to compare the effect of early versus delayed rehabilitation programs on shoulder pain, shoulder function, shoulder Range of Motion and the integrity of repaired tendon in primary arthroscopic rotator cuff repair secondary to full-thickness tear. We assumed that early passive ROM following arthroscopic rotator cuff repair has a significant effect on ROM, scapular protraction and upward rotation, shoulder pain and function, and failure rate compared to the delayed ROM protocol.

Patients and methods

Study Design

A parallel group randomized clinical trial comparing the effect of timing of ROM exercises on shoulder pain function, ROM, tendon integrity following arthroscopic repair of full thickness RCT.

Participants

Thirty patients, 15 in each group, were recruited from physical therapy Outpatient Clinic, Kasr Al-Ainy, Cairo University Hospitals. They were recruited between January 2021 and April 2022. They were eligible for inclusion based on the following criteria 1) primary arthroscopic rotator cuff repair secondary to full-thickness tear; 2) age ranges between 40 and 65 years; 3) approved to participate in postoperative rehabilitation and followed for 6-month postoperative to assess tendon integrity post rehabilitation, (4) able to read and write in Arabic. Participants were excluded based on the following criteria 1) Previous shoulder surgery to the affected shoulder; 2) prior shoulder stiffness; 3) repair of recurrent RCT, 4) concomitant glenohumeral injuries; 5) partial thickness tears (>3 cm in size).

The current study protocol was approved by the Institutional Ethical Review Board. An informed consent was obtained from all subjects before participation and as a part of ethical approval, they were free to drop out at any time without reason. The intervention was delivered by the first author (Waleed S. Ahmed) and patient selection in each group were upon surgeon's request. Therefore, it was not possible to blind participants and physiotherapists, due to the nature of interventions and surgical opinion.

Post operative rehabilitation

The ROM exercises timing was two weeks post operative in Group (A) and six weeks post operative in Group (B). Both groups underwent 4 phases of treatment protocol as following:

Phase I: Immobilization and Maximum Protection phase which extends for 2 weeks for Group (A) and 6 weeks for Group (B). The patients were instructed to wear abduction sling, doing elbow, wrist and hand ROM exercises and grip strengthening exercises as a home program.

Phase II: passive range of motion phase which extends for 4 weeks following Phase I. Passive arm elevation exercises while the patient is in supine on bed (fig. 1) and passive internal rotation behind the back while the patient is in sitting on a chair. All passive ROM exercises were hold for 10 seconds then relax for 3 sets of 10 repetition according to the patient's tolerance of pain. Furthermore, pendulum exercises were performed from prone lying position with affected shoulder out of the bed. Moreover, stretching of glenohumeral posterior capsule were applied 3 times with a holding time of 30 seconds and 10 seconds rest period between repetitions (fig. 2).

Figure 1. Passive ROM exercises

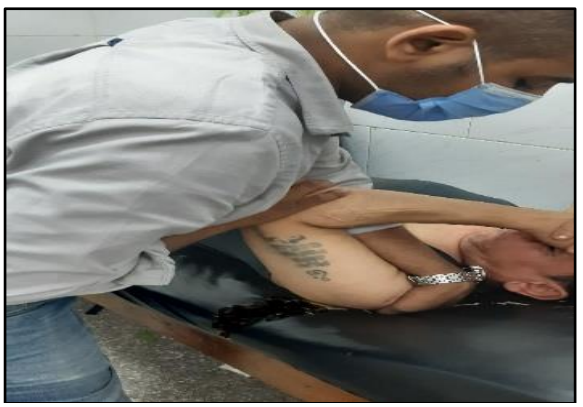

Figure 2. Stretching of glenohumeral posterior capsule.

Phase III: Active assisted and active range of Motion phase which extend for 4 weeks after the end of Phase II. Active assisted arm elevation in all directions of shoulder motion. Active assisted shoulder flexion with wand were performed to the limit of pain and discomfort at supine position (fig. 3). Furthermore, active assisted external rotation using wand then active ROM exercises (fig. 4) in all directions.

Figure 3. Active assisted shoulder elevation

Figure 4. Active assisted shoulder external rotation

Phase IV: Isometric Exercise and Resisted Exercises phase which extend for 4 weeks following Phase III. Isometric training for all shoulder muscles were performed in addition to rhythmic stabilization, cool's scapular training (fig. 5), TheraBand diagonal-up and TheraBand diagonal-down exercises (fig. 6).

Figure 5. Cool’s scapular training

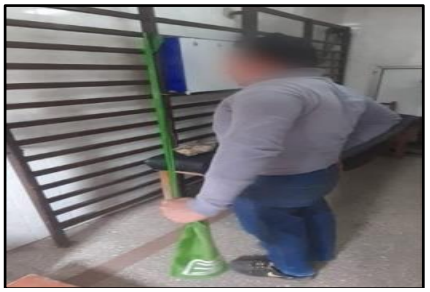

Figure 6. TheraBand diagonal-down exercise

Follow-up visits were at 6 weeks, 3 months, and 6 months postoperative. Shoulder pain, function, ROM, and tendon integrity were assessed in every visit.

Assessment of Pain, Function, and ROM

Shoulder function and pain severity were assessed by shoulder pain and disability index (SPADI) (7). Shoulder forward flexion, shoulder abduction and shoulder internal rotation ROM were assessed by universal goniometer according to the standard method of assessment described elsewhere (8). Scapular upward rotation was measured by two bubble inclinometers. One inclinometer was secured perpendicular to the shaft of the humerus above the humeral epicondyle. After good fixation, the resting position of the humerus was recorded and saved. Next, the patient was asked to move their shoulder into abduction while the elbow is in full extension and wrist in neutral position and the thumb leading to confirm that the inclinometer in vertical alignment. The patient was asked to stop movement of shoulder abduction at 45°, 90° and 135°. At the previous abduction positions, the scapular upward rotation was recorded and saved with the other bubble inclinometer that was secured over the spine of the scapula (fig. 7). The overall intra-rater reliability of this method of assessment is very good (ICC=0.88), and ranges from 0.81 to 0.94 (5).

Scapular protraction was assessed while the patient in lying supine and was asked to relax. The distance between the table and the posterior border of the acromion was assessed by an electronic digital caliper (fig. 8). The distance was recorded and saved in millimeters and called AT-distance as described by Host (9).

Fig 7. Scapular upward rotation assessment.

Fig 8. Measuring scapular protraction

Assessment of Tendon Integrity

Diagnostic ultrasonography was performed at 6 months post-operative follow up session to assess the healing and quality of RC repair. The images were reviewed by experienced radiologists who was informed that all patients had an arthroscopic repair secondary to full thickness RCT. They were blinded to the size and location of the RC tear that had been repaired. The scanner was placed in a sagittal position, which is in line with the fibers of the supraspinatus tendon and its insertion onto the greater tuberosity. The scanner was moved anteriorly until it reaches the bicipital groove and the subscapularis tendon. The scanner then moved back posteriorly until tendons of the infraspinatus and teres minor were visualized. During assessment of the RC tendon, the arm was gently abducted and adducted to determine the integrity of the attachment of the tendons to the bone. By rotating the scanner 90 degrees the rotator cuff tendons are viewed in the transverse plane (10).

The repair is considered intact if: 1) we see a bulky tendon; 2) the tendon can be moved synchronously with the humeral head; and 3) is attached to a visible anchor in the footprint. If these three signs cannot be visualized the repair is assumed failed and the tendon were considered ruptured (10).

Statistical analysis

Unpaired t-test was used for age comparison between groups and Chi-squared test for gender and distribution of the affected side. The normal distribution of data was checked by the Shapiro-Wilk test and Levene's test for homogeneity of variances between groups. Mixed MANOVA was used to investigate the effect of treatment on shoulder forward flexion, abduction, internal rotation ROM, scapular protraction and SPADI. Post-hoc tests using the Bonferroni correction were used for multiple group comparisons. Scapular upward rotation was compared between groups by unpaired t-test and between 3 and 6 months by paired t-test. The significance lever for the statistical tests was set at $p < 0.05$. All statistical analysis was performed by the statistical package software for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics

There was no significant difference between groups in age, sex and distribution of the affected side ($p > 0.05$) as shown in table 1.

Table 1.
Demographic characteristics for group A and B

Characteristics	Group A (n = 15)	Group B (n = 15)	p-value
Age (years), mean ± SD	52.4 ± 5.65	53.06 ± 7.64	0.78
Sex, n (%) Males Females	 6 (40%) 9 (60%)	 5 (33%) 10 (67%)	0.71
affected side, n (%) Right Left	 6 (40%) 9 (60%)	 7 (47%) 8 (53%)	0.71

p value, Probability value, SD, Standard deviation

Effect of treatment on flexion, abduction, internal rotation ROM, scapular protraction and SPADI

Mixed MANOVA found that there was a significant effect for treatment and time ($F = 9.27$, $p = 0.001$). The significant effect of time was $F = 357.72$, $p = 0.001$. The significant effect of treatment was $F = 49.28$, $p = 0.001$.

The comparison within groups

There was a significant increase in flexion, abduction and internal rotation ROM at 6 months post treatment compared to that at 6 weeks and 3 months ($p < 0.001$), and a significant increase at 3 months post treatment compared to that at 6 weeks in both groups ($p < 0.001$). There was a significant reduction in scapular protraction ROM at 6 months post treatment compared to that at 6 weeks and 3 months ($p < 0.01$), and a significant decrease at 3 months post treatment compared to that at 6 weeks in both groups ($p < 0.001$). There was a significant reduction in SPADI at 6 months post treatment compared to that at 6 weeks and 3 months ($p < 0.001$), and a significant decrease at 3 months post treatment compared to that at 6 weeks in both groups ($p < 0.001$). (Table 2).

The comparison Between group

There was a significant increase in flexion, abduction and internal rotation ROM at 6 weeks, 3 months and 6 months in group A when compared to that of group B ($p < 0.01$). There was a significant increase in protraction ROM at 6 weeks, 3 months and 6 months in group B compared to that of group A ($p < 0.01$). There was a significant decrease in SPADI of group A compared to that of group B at 6 weeks ($p < 0.001$), while there was no significant difference at 3 months and at 6

months (p > 0.05). (Table 2).

Scapular upward rotation

There was a significant decrease in scapular upward rotation at 45º and 90º at 6 months compared to that at 3 months in group A and B (p < 0.01). There was no significant difference between groups in scapular upward rotation at 45º, 90º and 135º ROM at 3 months and at 6 months (p > 0.05). (Table 3).

Tendon integrity

The distribution of tendon integrity in group A revealed that 12 (80%) subjects had intact tendon while 3 (20%) subjects had failed tendon. The distribution of tendon integrity in group B revealed that 15 (100%) subjects had intact tendon. There was no significant difference between early and delayed ROM in the distribution of tendon integrity (p = 0.22).

Table 2.
Mean shoulder ROM, Protraction ROM and SPADI at 6 weeks, 3 months and 6 months of group A and B

	6 weeks	3 months	6 months	p-value		
	mean ± SD	mean ± SD	mean ± SD	6 weeks vs. 3 months	6 weeks vs. 6 months	3 months vs. 6 months
Flexion ROM (degrees)						
Group A	92 ± 9.59	143 ± 10.14	169 ± 8.28	0.001*	0.001*	0.001*
Group B	71.33 ± 11.25	125 ± 12.39	154.33 ± 9.79	0.001*	0.001*	0.001*
MD	20.67	18	14.67			
	p = 0.001*	p = 0.001*	p = 0.001*			
Abduction ROM (degrees)						
Group A	82 ± 7.02	121 ± 10.38	155 ± 8.01	0.001*	0.001*	0.001*
Group B	60.66 ± 7.76	108.66 ± 12.74	145.66 ± 11.62	0.001*	0.001*	0.001*
MD	21.34	12.34	9.34			
	p = 0.001*	p = 0.007*	p = 0.01*			
Internal rotation ROM (degrees)						
Group A	46.33 ± 2.96	70 ± 8.66	76.33 ± 4.41	0.001*	0.001*	0.001*
Group B	25.66 ± 4.16	46 ± 8.06	70 ± 6.26	0.001*	0.001*	0.001*
MD	20.67	24	6.33			
	p = 0.001*	p = 0.001*	p = 0.003*			
Protraction ROM (degrees)						
Group A	32.2 ± 3.78	27.2 ± 2.21	24.4 ± 2.66	0.001*	0.001*	0.001*
Group B	36.66 ± 3.81	32.13 ± 3.72	28.13 ± 2.41	0.001*	0.001*	0.001*
MD	-4.46	-4.93	-3.73			
	p = 0.003*	p = 0.001*	p = 0.001*			
SPADI (%)						
Group A	81.8 ± 5.6	51.24 ± 13.47	12.8 ± 14.36	0.001*	0.001*	0.001*

Group B	92.11 ± 7.48	54.39 ± 15.23	7.97 ± 3.89	0.001*	0.001*	0.001*
MD	-10.31	-3.15	4.83			
	p = 0.001*	p = 0.55	p = 0.22			

MD, Mean difference; p value, Probability value; SD, Standard deviation
* Significant differences between groups

Table 3.
Mean scapular upward rotation of group A and B

Scapular upward rotation *(degrees)*	3 months mean ± SD	6 months mean ± SD	MD	t-value	p value
at 45º ROM					
Group A	16 ± 3.52	13.2 ± 1.93	2.8	3.47	0.004*
Group B	14.33 ± 2.52	12.53 ± 1.81	1.8	4.73	0.001*
MD	1.67	0.67			
t- value	1.48	0.97			
	p = 0.14	*p = 0.33*			
at 90º ROM					
Group A	38 ± 3.21	35.4 ± 3.85	2.6	2.75	0.01*
Group B	38.8 ± 2.48	35.27 ± 2.08	3.53	6.04	0.001*
MD	-0.8	0.13			
t- value	-0.76	0.11			
	p = 0.45	*p = 0.91*			
at 135º ROM					
Group A	-	49.4 ± 5.8			
Group B	-	48.8 ± 2.7			
MD		0.6			
t- value		0.36			
		p = 0.71			

MD, Mean difference; p value, Probability value; SD, Standard deviation
* Significant difference between groups

Discussion

After arthroscopic rotator cuff repair, the ideal timing to start postoperative range of motion is still up for dispute. Therefore, the aim of the current study is to compare the effect of early versus delayed rehabilitation programs on shoulder pain, function, Range of Motion, and tendon integrity in primary arthroscopic rotator cuff repair secondary to full-thickness tear. Early rehabilitation program was effective to improve function and reduce pain only for short term (6 weeks) postoperative compared to late rehabilitation program. On the other hand, both programs were effective for long-term (3-6 months) concerning pain reduction and functional improvement.

Shoulder ROM was improved in all examined directions including flexion, abduction, and external rotation in early group in all follow-up periods compared to late group. The results were anticipated because starting early motion facilitates joint mobility and prevent formation of intraarticular fibrous tissue associated with adhesion and joint stiffness. On the other hand, scapular upward rotation improvement didn't significantly differ between groups which may be attributed to the nature of ROM exercises used in the current protocol which may be generalized rather that specific to improve scapular mobility.

Normal activities and functional stresses are essential factors for restoration of normal tissue biology following injury. A balance between the load intensity and the biological healing processes are essential in the design of rehabilitation protocols for injured tissues. This balance is critical to enhance proper structural organization and hence facilitate its biomechanical properties and on the other hand, avoid structural failure. Assessment of timing and intensity of exercises after arthroscopic repair of rotator cuff tear was first examined on animals. Immobilization following rotator cuff repair in sheep was associated with superior structural and material properties and further facilitated gene expression of collage fibers at tendon insertion compared to exercise group. Therefore, they suggested that the quality of tissue healing, and tissue organization was enhanced with decreased loading (11). On the other hand, shoulder pain and ROM was deteriorated, and shoulder stiffness was associated with deterioration of short-term functional outcomes secondary to immobilization in rats (12).

The pattern of improvement of shoulder pain and function observed in our current work appear in parallel with previous research examined aggressive passive ROM following rotator cuff repair. Aggressive postoperative passive ROM succeeded to improve shoulder ROM, but it may compromise tendon healing (13). On the other hand, better functional recovery was observed with an accelerated rehabilitation program and rapid return to normal activities compared to restricted rehabilitation program (14).

There were discrepancies in the literature on the ideal time for passive ROM exercises or the ideal period of immobilization of repaired tendon. Shoulder immobilization in abduction sling may extend up to 5 weeks postoperative (15) or may only for the first week and then active mobilization may be recommended (16). Furthermore, the type of rehabilitation program and exercises used, especially those used immediately after surgery, showed greater differences and wide variations in previous studies. Weber and Torrey (2012) examined the effect supervised home passive ROM and pendulum exercises at 5 to 7 days postoperatively. Furthermore, they compared the results with the same exercises but after three weeks postoperative. Each groups started active-assisted motion at the end of 6 weeks. The results confirmed that delayed rehabilitation intervention was associated with functional deterioration and delayed motion recovery compared to early intervention (16).

The shoulder ROM improvements observed in the current work come in parallel with several studies compared early versus delayed intervention on joint mobility. They confirmed that early intervention associated with better joint motion and hence good functional recovery (13, 16-18). But on the long-term observation,

both early and delayed programs were effective to regain joint motion at 1-year follow-up especially shoulder internal and external rotation ROM (17).

A recent study by Kjær and his colleagues (2021) comparing progressive active ROM exercises and limited passive ROM exercise after surgical repair of rotator cuff tear concluded similar functional recovery after 1 year follow up. Furthermore, similar results were observed in pain and shoulder ROM and strength at the same period. Moreover, similar rate of tendon retear was further reported at both group with minimal number at progressive active exercise therapy and also observed in previous related studies (19). The opposite was observed in the current study in which tendon retear was observed in early ROM group compared to early immobilization group although these differences failed to reach statistical significance.

Mazzocca and his coworkers (2017) compared the effect of early versus delayed ROM protocols on repair integrity, clinical outcomes as pain and function, and quality of life in arthroscopic single-tendon rotator cuff repair. They concluded that both early and late mobility groups had a similar improvement, suggesting that both protocols had the same effect on measured outcomes. Although failure rates were similar between groups, the sample size was insufficient to support statements regarding the relationship between tear quality and treatment protocols (19). A recent systematic review suggested that patients undergoing early rehabilitation regain ROM more quickly and are not at increased risk of compromising tendon integrity which represents a major concern among clinicians (20).

Scapular dyskinesis (SD) was frequently observed in patients with rotator cuff tears and after reconstructive surgery with a higher prevalence rate. Postoperative rehabilitation improved SD in 50% of cases and furthermore improvements were also observed in rotator cuff function and tendon healing (21). The current study observed that there was a significant reduction in scapular protraction in early rehabilitation group A compared to higher values of protraction observed at immobilization group B. The observed improvement of scapular protraction in the early rehabilitation group may be attributed to reduction of SD which is associated with pain and functional improvements.

On the other hand, there was no statistically significant difference between early and late groups in scapular upward rotation at 45º, 90º and 135º ROM of shoulder abduction. Ueda and his colleagues (2019) observed that scapular movement did not recover after rehabilitation to the same level as that of the healthy controls (22). In contrast to this observation, another study reported that small and large RCT patients had higher scapular upward rotation during arm elevations compared to healthy controls (23). The observation may necessities the need for a higher quality clinal trials to examine the effect of specific scapular training post operative to regain normal scapular rhythm

The finding of the current study has some limitations in which the included patients were undergoing primary arthroscopic rotator cuff repair secondary to full thickness tear, therefore, our finding is limited to that population. The type of rotator cuff tear ranges from partial to full thickness tear and the surgical repair

techniques were also vary which may limit the comparability between trials. Furthermore, the wide variations of rehabilitation protocols and their timing may further explain the several contradictions in the reported outcomes between current results and similar trials. Moreover, relative low sample size may further limit the generalizability of our findings.

Early ROM exercises is quite different than aggressive exercises. Therefore, it is recommended that early motion to be unified and comprehensive to mobilize joint, stimulate muscle and promote function without overloading the repaired tissue to maintain its integrity. Therefore, standardized comprehensive rehabilitation protocol is needed to obtain both structural and functional improvements.

Conclusion

The results suggested that early passive ROM may be recommended after primary arthroscopic rotator cuff repair secondary to full thickness tear because the shoulder ROM were better at all follow-up periods in early ROM group compared to immobilization group. Furthermore, early ROM exercises succeeded to improve shoulder function and reduce pain without compromising tendon integrity.

Competing interests

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Authors declare that there were no competing interests

Source of funding
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References

1. Arndt J, Clavert P, Mielcarek P, Bouchaib J, Meyer N, et al. (2012) Immediate passive motion versus immobilization after endoscopic supraspinatus tendon repair: a prospective randomized study. Orthop Traumatol Surg Res. 98:S131-138.
2. Beer J de, Karelse Anne. Sonographic evaluation of the arthroscopically repaired rotator cuff. SAOJ 2009, 50-55
3. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, et al. (2005) Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am 87: 1229-1240.
4. Cuff DJ, Pupello DR: Prospective randomized study of arthroscopic rotator cuff repair using an early versus delayed postoperative physical therapy protocol. J Shoulder Elbow Surg 2012; 21(11):1450-1455.
5. Dan L. Riddle, Jules M. Rothstein, Robert L. Lamb, Goniometric Reliability in a Clinical Setting: Shoulder Measurements, *Physical Therapy*, Volume 67, Issue 5, 1 May 1987, Pages 668–673
6. Düzgün I, Baltaci G, Atay OA: Comparison of slow and accelerated rehabilitation protocol after arthroscopic rotator cuff repair: Pain and functional activity. Acta Orthop Traumatol Turc 2011;45(1):23-33.
7. Gajera, D., Bhanawat, S., Gurjar, V., Maharaul, H. H., & Gandhi, J. P. (2022). Laproscopic versus open ventral hernia repair. *International Journal of*

Health Sciences, *6*(S4), 1795–1800. https://doi.org/10.53730/ijhs.v6nS4.6478
8. González, A. E. D., Arauz, W. M. S., Gámez, M. R., & Alava, L. A. C. (2017). Photovoltaic energy to face an earthquake. *International Journal of Physical Sciences and Engineering*, *1*(3), 19–30. https://doi.org/10.21744/ijpse.v1i3.61
9. Guermazi M, Ghorbel S, Yahia S et al (2011) Arabic translation and validation of the SPADI index. Ann Phys Rehabil Med 54:228–244.
10. Host HH. Scapular taping in the treatment of anterior shoulder impingement. Phys Ther 1995;75:803–12.
11. Keener JD. Revision rotator cuff repair. Clin Sports Med 2012;31:713–25.
12. Kim YS, Chung SW, Kim JY, Ok JH, Park I, Oh JH: Is early passive motion exercise necessary after arthroscopic rotator cuff repair? Am J Sports Med 2012;40(4):815-821.
13. Kjær BH, Magnusson P, Henriksen, Warming S: Effects of 12 Weeks of Progressive Early Active Exercise Therapy After Surgical Rotator Cuff Repair 12 Weeks and 1-Year Results From the CUT-N-MOVE Randomized Controlled Trial. Am J Sports Med 2021;49(2):321–331.
14. Lee BG, Cho NS and Rhee YG. Effect of two rehabilitation protocols on range of motion and healing rates after arthroscopic rotator cuff repair: aggressive versus limited early passive exercises. Arthroscopy 2012; 28: 34-42.
15. Lewis, C. W., Schlegel, T. F., Hawkins, R. J., James, S. P., & Turner, A. S. (2001). The effect of immobilization on rotator cuff healing using modified Mason-Allen stitches: a biomechanical study in sheep. Biomedical sciences instrumentation, 37, 263–268.
16. Lin TW, Cardenas L, Soslowsky LJ. Biomechanics of tendon injury and repair. J Biomech 2004;37:865–77.
17. Mazuquin B, Moffatt M, Gill P, Selfe J, Rees J, Drew S, Littlewood C. Effectiveness of early versus delayed rehabilitation following rotator cuff repair: Systematic review and meta-analyses. PLoS One. 2021 May 28;16(5):e0252137. doi: 10.1371/journal.pone.0252137. PMID: 34048450; PMCID: PMC8162656.
18. Mazuquin, B. F., Wright, A. C., Russell, S., Monga, P., Selfe, J., & Richards, J. (2018). Effectiveness of early compared with conservative rehabilitation for patients having rotator cuff repair surgery: an overview of systematic reviews. British journal of sports medicine, 52(2), 111–121. https://doi.org/10.1136/bjsports-2016-095963
19. Mazzocca AD, Arciero RA, Shea KP, Apostolakos JM, Solovyova O, Gomlinski G, Wojcik KE, Tafuto V, Stock H, Cote MP. The Effect of Early Range of Motion on Quality of Life, Clinical Outcome, and Repair Integrity After Arthroscopic Rotator Cuff Repair. Arthroscopy. 2017 Jun;33(6):1138-1148. doi: 10.1016/j.arthro.2016.10.017. Epub 2017 Jan 19. PMID: 28111006.
20. Mell, A.G., LaScalza, S., Guffey, P., Ray, J., Maciejewski, M., Carpenter, J.E., et al., 2005. Effect of rotator cuff pathology on shoulder rhythm. J. Shoulder Elb. Surg. 14 (1), 58–64. https://doi.org/10.1016/j.jse.2004.09.018.
21. Sarver, J. J., Peltz, C. D., Dourte, L., Reddy, S., Williams, G. R., & Soslowsky, L. J. (2008). After rotator cuff repair, stiffness--but not the loss in range of motion--increased transiently for immobilized shoulders in a rat model. Journal of shoulder and elbow surgery, 17(1 Suppl), 108S–113S. https://doi.org/10.1016/j.jse.2007.08.004

22. Song, H.E., Oh, KS., Yoon, J.P. et al. Improvement in scapular dyskinesis after rotator cuff repair and subacromial decompression. Knee Surg Sports Traumatol Arthrosc 29, 3961–3970 (2021). https://doi.org/10.1007/s00167-021-06681-x
23. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2022). Post-pandemic health and its sustainability: Educational situation. *International Journal of Health Sciences*, *6*(1), i-v. https://doi.org/10.53730/ijhs.v6n1.5949
24. Ueda Y, Tanaka H, Morioka S, et al., Comparison of scapular upward rotation during arm elevation in the scapular plane in healthy volunteers and patients with rotator cuff tears pre- and post-surgery. Clin Biomech (Bristol, Avon) 2019;63:207–213.
25. Watson L, Balster SM, Finch C, et al. Measurement of scapula upward rotation: a reliable clinical procedure. Br J Sports Med 2005;39:599–603.
26. Weber SC, Torrey D: Early versus delayed rehabilitation in arthroscopic rotator cuff surgery: : A Dual Surgeon Comparative Cohort Study (SS-15). Arthroscopy: The Journal of Arthroscopic & Related Surgery. 28. e9–e10. 10.1016/j.arthro.2012.04.075.