Effect Of Modified Hand Position During Circuit Resistance Training On Improving Shoulder Kinematics In Paraplegic Patients

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Abstract:* Background: Most paraplegic patients report shoulder pain due to considerable stress placed on the shoulder by wheelchair propulsion and other activities of daily living. Wheelchair-based circuit resistance training (CRT) should promote favourable shoulder kinematics to protect the shoulder from mechanical impingement following paraplegia. The purpose of the study was to investigate the effect of circuit resistance training with modified hand position on shoulder kinematics in paraplegic patients. Methods: Thirty patients from both gender, aged from 40 to 60 years, with shoulder pain due to paraplegia participated in this study. They were assigned randomly into two equal groups: (Study Group) performed CRT with modified hand position and (Control Group) performed CRT with traditional hand position. Both groups received conventional physiotherapy program (2 sessions per week for 2 months). The patients were evaluated by numeric rating scale (NRS) for assessment of pain intensity, electrical goniometer for assessment of shoulder joint range of motion (ROM) and 3- D ultrasonography for assessment of subacromial space. Results: There was a significant decrease in pain intensity and a significant increase in the shoulder ROM in both groups after treatment with the best results for study group. The study group showed significant improvement in subacromial joint space, whereas the control group showed no improvement. Conclusion: Hand position alters kinematics during CRT and should be selected to emphasize healthy shoulder mechanics.
Key words: Paraplegia, shoulder pain, CRT, subacromial space.

1. INTRODUCTION:

Manual wheelchair use in paraplegic patients places considerable stress on the upper limbs, particularly the shoulder, due to the repetitive loading induced by wheelchair propulsion in addition to other activities of daily living. Given the limited muscle mass and low stability, yet high mobility of the shoulder girdle, these activities often lead to pain, with up to 71% of manual wheelchair users reported to have experienced shoulder pain at some point in their life **[1]**.

Patients with spinal cord injury (SCI) and shoulder pain often have injured rotator cuff tendons. The rotator cuff tendons can get overcrowded or pinched, which is called subacromial impingement. This pinching can be painful, or it can cause tears to the tendons which can be painful. Once a tendon is torn, it may be more difficult to move the shoulder properly, which can lead to further damage. Therefore, it is recommended that people treat shoulder pain rather than just live with it **[2,3].**

Circuit resistance training (CRT) is one form of exercise that is recommended across the rehabilitation spectrum to facilitate independent functioning with the upper extremities. Despite the evidence to support physiological benefits of CRT exercise, few studies in the able-bodied or SCI literature have analysed or verified which exercises to select based on kinematic rationale for minimizing mechanical impingement risk. Further, it is also unknown whether modifications to the exercises via changes in hand position can favourably influence kinematics during CRT **[4]**.

Subjects, material & methods:

Thirty patients from both gender (40 – 60 years) with shoulder pain due to paraplegia were selected from outpatient clinic of Shebin El-Kom teaching hospital and Menoufia university hospital, Menoufia, Egypt. To be included in the study, the patients were greater than six months post SCI from trauma, vascular or orthopedic origin and the SCI was at 2nd thoracic level or below. The patients were depending on manual wheelchair for primary mobility and free of cognitive dysfunction. The exclusion criteria were chronic diabetes, trauma, dislocation or surgery to the glenohumeral or acromioclavicular joints.

The patients were assigned randomly into two equal groups: *Study group (A)* consisted of fifteen patients that received conventional physiotherapy program in addition to CRT with modified hand position (2 sessions per week for 2 months) and *Control group (B)* consisted of fifteen patients that received the same conventional physiotherapy program in addition to CRT with traditional hand position (2 sessions per week for 2 months).

The conventional physiotherapy program:

Consisted of therapeutic ultrasound, transcutaneous electrical nerve stimulation (TENS), strengthening exercises for weak shoulder muscles and stretching for tight muscles and shoulder capsule".

The therapeutic ultrasound: The manufacturer of the device is Gymna, with a model: PULSON 400 and its origin is Belgium. The transducer head was applied over the glenohumeral joint and slow circular movements were done covering an area of approximately 10 cm^2. Continuous ultrasound was used with the following parameters (frequency of 1MHz, at an intensity of 1.5 Watt/ cm^2, for 8 minutes) **[5].**

Transcutaneous Electrical Nerve Stimulation: The manufacturer of the device is Medical Italia, with a model of: THERAPIC 9200 and its origin is Italy. The electrodes were placed on the anterior and lateral aspects of the shoulder for 15 min., with action 2 sec., pause 3 sec., frequency 120 Hz and impulse time 50 µsec.

The conventional physiotherapy program acts on coupling system around shoulder. The first one is between the rotator cuff and deltoid (tight muscle is subscapularis and weak muscles are infraspinatus, teres minor and deltoid). The second one is between trapezius and serratus anterior (tight muscle is upper trapezius and weak muscles are lower trapezius and serratus anterior).

Circuit resistance training (CRT):

Consisted of 5 resistance exercises (overhead press, overhead pull, chest press, horizontal row and downward press). Each exercise was completed over six seconds, and five minutes of rest were allowed between exercises. The protocol for traditional hand positions was selected based on the manufacturer's recommended position. The modified hand position was selected based on the ultimate goal of maximizing overall favourable shoulder kinematics (scapular posterior tilt, upward rotation and glenohumeral external rotation) for each exercise. Modified hand positions were within the capacity of the equipment **[4]**.

A) *Modified hand position:*

In the overhead press, the patient was asked to grasp perpendicular handles and press straight up ***(fig. 1)***.

In the chest press, the handle position was adjusted so that, when grasped, elbows are at the side. The patient was asked to grasp vertical handles, keep elbows at side then to extend elbows ***(fig. 2)***.

In the overhead pull, the handle position height was adjusted. The patient was asked to grasp bar outside shoulder width with palms up then to bend arms, bringing bar down in front of face, and return elbows to side of body ***(fig. 3)***.

In the horizontal row, the chest pad was adjusted to allow grasp of handle with arms fully extended. The patient was asked to grasp vertical handles then to bend arms and bring elbows beside body ***(fig. 4)***.

In the downward press, the handles were centred between greater trochanters and lateral femoral condyles. With thumbs pointing forward, the patient was asked to grasp handles horizontally, lean forward and press straight toward the floor with elbow extension and shoulder depression ***(fig. 5)***.

B) Traditional hand position:

In the overhead press, the patient was asked to grasp horizontal handles and press straight up ***(fig. 6)***.

In the chest press, the handle position was adjusted so that, when grasped, upper arms are straight to side. The patient was asked to grasp horizontal handles, keep elbows out to the side, then to extend elbows ***(fig. 7)***.

In the overhead pull, the handle position height was adjusted. The patient was asked to grasp bar outside shoulder width with palm down then to bend arms, bringing bar down in front of face, and return elbows to side of body ***(fig. 8)***.

In the horizontal row, the chest pad was adjusted to allow grasp of handle with arms fully extended. The patient was asked to grasp horizontal handles then to bend arms and bring elbows beside body ***(fig. 9)***.

In the downward press, the handles were centred between greater trochanters and lateral femoral condyles. With thumbs pointing forward, the patient was asked to grasp handles perpendicularly, lean forward and press straight toward the floor with elbow extension and shoulder depression ***(fig. 10)***.

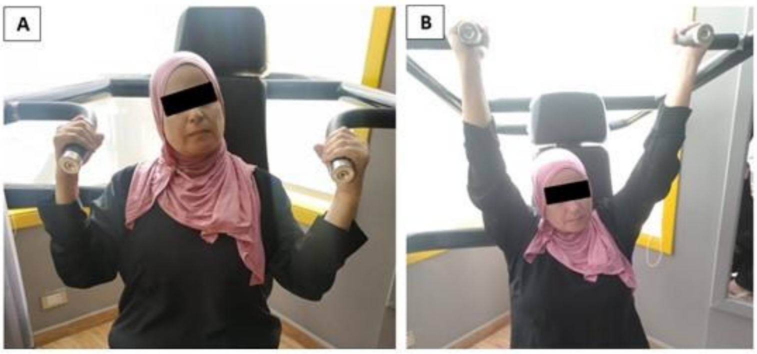

Fig (1): Overhead press with modified hand position: (A) start, (B) end of the movement.

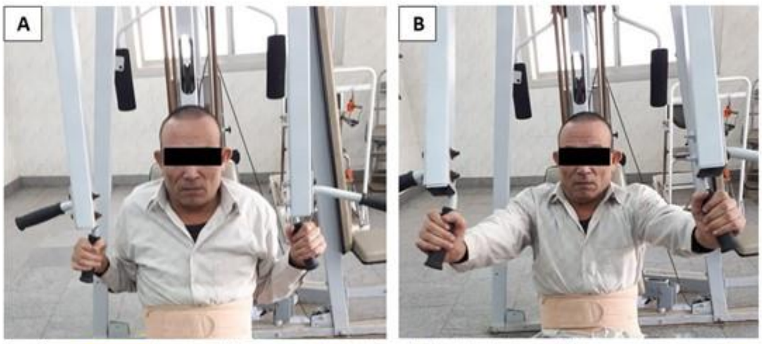

Fig (2): Chest press with modified hand position: (A) start, (B) end of the movement.

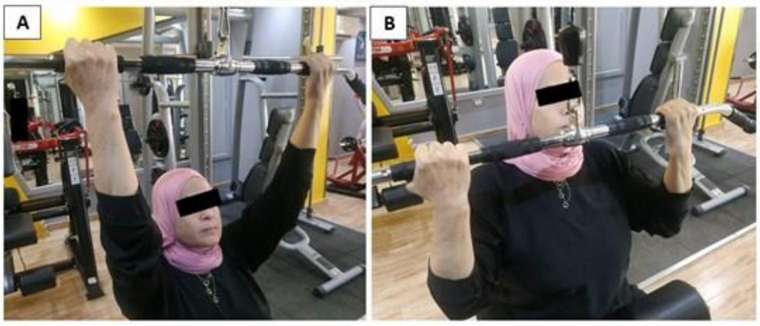

Fig (3): Overhead pull with modified hand position: (A) start, (B) end of the movement.

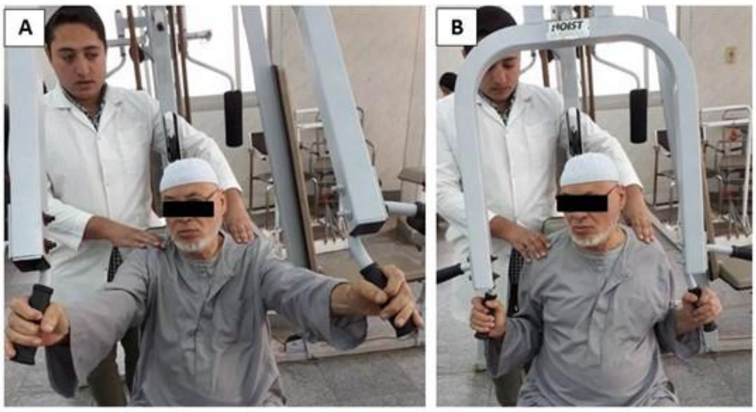

Fig (4): Horizontal row with modified hand position: (A) start, (B) end of the movement.

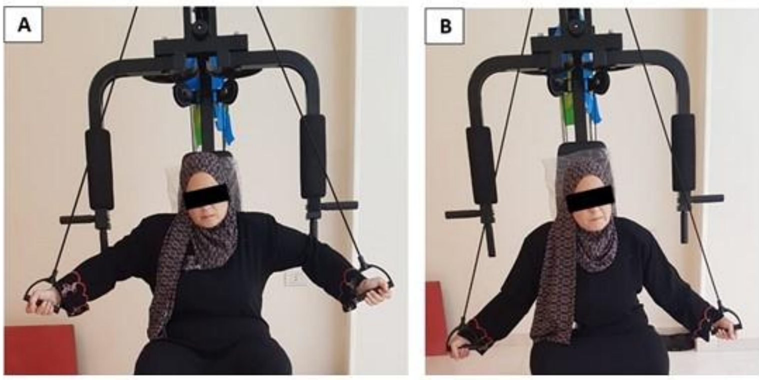

Fig (5): Downward press with modified hand position: (A) start, (B) end of the movement.

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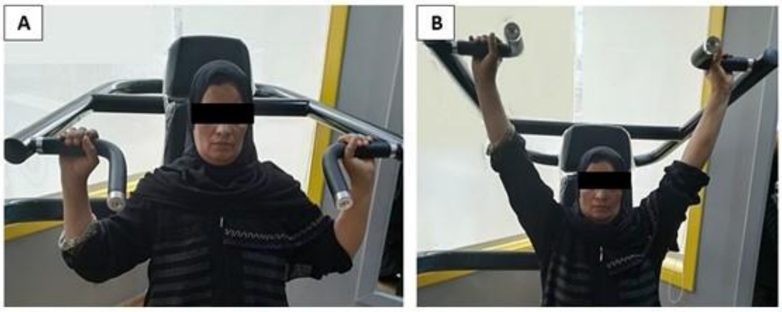

Fig (6): Overhead press with traditional hand position: (A) start, (B) end of the movement.

Fig (7): Chest press with traditional hand position: (A) start, (B) end of the movement.

Fig (8): Overhead pull with traditional hand position: (A) start, (B) end of the movement.

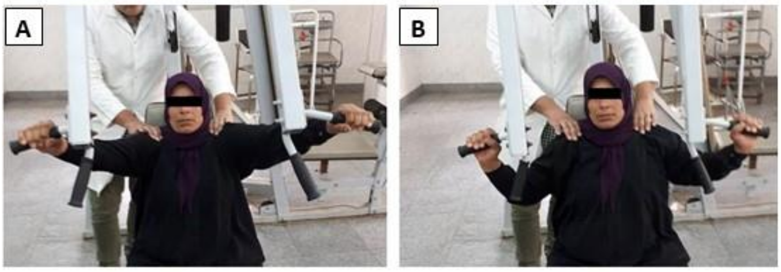

Fig (9): Horizontal row with traditional hand position: (A) start, (B) end of the movement.

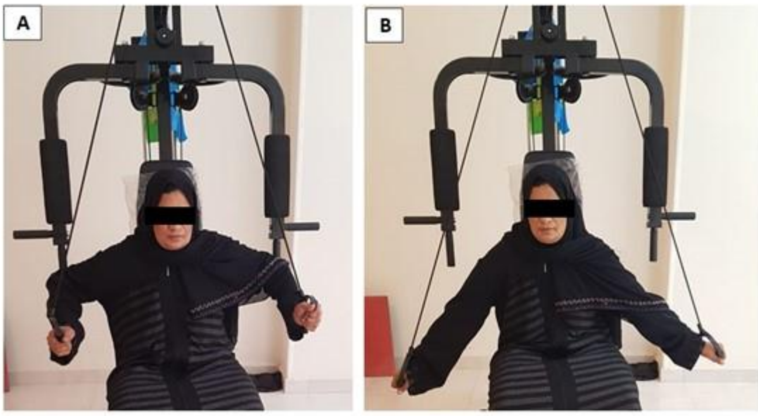

Fig (10): Downward press with traditional hand position: (A) start, (B) end of the movement.

All patients were subjected to the following evaluation procedures, once before and again at the end of the treatment program:

- ***3- D ultrasonography:*** for assessment of subacromial space as an indicator of shoulder kinematics.
- ***Numeric rating scale (NRS):*** for assessment of pain intensity.
- ***Electrical goniometer:*** for assessment of range of motion (ROM) of shoulder joint. The goniometer used is Metal Absolute + Axis Goniometer- digital with 180 degrees range and 9 inches arms. It's powered by 1 x 9 v battery, included. The manufacturer of the device is Baseline.

At the end of the study, the data were collected, descriptive statistics were presented as mean ± standard deviation (SD). ANOVA test was used to compare the mean values of the two groups and to compare the mean values pre and post treatment within the same group.

2. RESULTS:

I- General characteristics of the patients in both groups:

There was a non-significant difference between both groups in their ages, heights, weights, and BMI ***(Table 1)***.

Table (1): General characteristics of the patients in both groups (A&B)

General characteristics	Study (GA)	Control (GB)	*t*	*P*	*S*
	Mean ±SD	Mean ±SD			
1- Age (years)	48.5± 3.14	48.7± 3.31	0.18	0.85	NS
2- Height (Cm.)	162.05 ± 8.06	161.88 ± 7.52	0.31	0.761	NS
3- Weight (Kg.)	70.88 ± 6.40	71.63 ± 6.21	1.76	0.086	NS
4-BMI (Kg/m^2)	23.54±0.74	23.51±0.56	0.15	0.87	NS

SD: standard deviation, P: probability, S: significance, NS: non-significant

II. Results of shoulder ROM and subacromial joint space:

There was a non-significant difference in the shoulder flexion, extension, abduction, medial rotation and external rotation ROM between pre-treatment results in both groups. Also, there was a non-significant difference in the subacromial joint space between pre-treatment results in both groups ***(Table 2)***.

Table (2): Comparison of the mean values of ROM of the patients in both groups pre-treatment

Item	Pre-treatment			
	Study (GA)	Control (GB)	t-value	*p*-value
	Mean ±SD	Mean ±SD		
1- Shoulder Flexion ROM	166.93 ± 2.21	168.40 ± 2.10	1.86	0.073
2- Shoulder Extension ROM	38.30 ± 0.941	39.07 ±1.49	1.69	0.105
3- Shoulder Abduction ROM	138.33 ± 1.35	138.67 ± 1.11	0.74	0.466
4- Shoulder Medial rotation ROM	46.10 ± 2.26	47.40 ± 1.64	1.80	0.083
5- Shoulder External rotation ROM	77.33 ± 1.68	77.40 ± 1.50	0.11	0.910
6- Sub Acromial Joint Space	5.79 ± 0.532	6.16 ± 0.794	1.51	0.144

*SD: standard deviation, P: probability, P > 0.05 = Non-significant, P ≤ 0.05 = significant**

There was a significant difference in the shoulder flexion, extension, abduction, medial rotation and external rotation ROM between pre and post treatment results in group (A). Also, there was a significant difference in the subacromial joint space between pre and post treatment results in group (A) ***(Table 3)***.

Table (3): Comparison of the mean values of ROM of patients in group A pre and post treatment.

Item	Study (GA)			
	Pre treatment	Post treatment	t-value	p-value
	Mean ±SD	Mean ±SD		
1- Shoulder flexion ROM	**166.93 ± 2.21**	**172.47 ±3.199**	**10.60**	**0.000**
2- Shoulder Extension ROM	**38.30 ± 0.941**	**42.27 ± 1.821**	**9.01**	**0.000**
3- Shoulder Abduction ROM	**138.33 ± 1.35**	**143.47±1.995**	**7.45**	**0.000**
4- Shoulder Medial rotation ROM	**46.10 ± 2.26**	**49.60 ± 3.001**	**5.00**	**0.000**
5- Shoulder External rotation ROM	**77.33 ± 1.68**	**83.60 ± 1.882**	**8.40**	**0.000**
6- Sub Acromial Joint Space	**5.79 ± 0.532**	**8.74 ± 1.492**	**8.41**	**0.000**

There was a significant difference in the shoulder flexion, extension, abduction and external rotation ROM between pre and post treatment results in group (B). However, there was a non-significant difference in the medial rotation ROM and the subacromial joint space between pre and post treatment results in group (B) ***(Table 4)***.

Table (4): Comparison of the mean values of ROM of patients in group B pre and post treatment

Item	Control (GB)			
	Pre treatment	Post treatment	t-value	p-value
	Mean ±SD	Mean ±SD		
1- Shoulder flexion ROM	**168.40 ± 2.10**	**170.13 ±2.200**	**6.10**	**0.000**
2- Shoulder Extension ROM	**39.07 ±1.49**	**40.27 ± 1.280**	**3.52**	**0.003**

3- Shoulder Abduction ROM	**138.67 ± 1.11**	**140.93 ±1.223**	**8.50**	**0.000**
4- Shoulder Medial rotation ROM	**47.40 ± 1.64**	**50.73 ± 6.55**	**1.95**	**0.071**
5- Shoulder External rotation ROM	**77.40 ± 1.50**	**79.87 ± 2.031**	**7.34**	**0.000**
6- Sub Acromial Joint Space	**6.17 ± 0.794**	**6.43 ± 0.678**	**1.52**	**0.150**

There was a significant difference in the shoulder flexion, extension, abduction and external rotation ROM between post treatment results in both groups. Also, there was a significant difference in the subacromial joint space between post treatment results in both groups. However, there was a non-significant difference in the medial rotation ROM between post treatment results in both groups ***(Table 5)***.

Table (5): Comparison of the mean values of ROM of patients in both groups post treatment

Item	**Post treatment**			
	Study (GA)	**Control (GB)**	**t-value**	***p*-value**
	Mean ±SD	**Mean ±SD**		
1- Shoulder flexion ROM	**172.47 ± 3.19**	**170.13 ±2.20**	**2.33**	**0.029**
2- Shoulder Extension ROM	**42.27 ± 1.82**	**40.27 ± 1.28**	**3.48**	**0.002**
3- Shoulder Abduction ROM	**143.47± 1.99**	**140.93 ±1.22**	**4.19**	**0.000**
4- Shoulder Medial rotation ROM	**49.60 ± 3.00**	**50.73 ± 6.55**	**0.61**	**0.550**
5- Shoulder External rotation ROM	**83.60 ± 1.88**	**79.87 ± 2.03**	**5.22**	**0.000**
6- Subacromial joint space	**8.74 ± 1.49**	**6.43 ± 0.68**	**5.47**	**0.000**

III. Shoulder pain intensity results:

There was a non-significant difference in pre-treatment values of pain intensity between groups A and B, while there was a significant difference in the post treatment values with the best results for the study group A ***(Table 6)***.

Table (6): Comparison between groups A & B for pain intensity pre and post treatment

	Pain Intensity values			
	Pre-treatment		**Post-treatment**	
	Group (A)	**Group (B)**	**Group (A)**	**Group (B)**
Mean	**6.13**	**6.33**	**2.00**	**5.13**
SD	**0.74**	**1.23**	**1.23**	**0.99**
z-value	**0.34**		**3.53**	
u-value	**219.5**		**127.5**	
P-value	**0.60**		**0.000**	
S	**NS**		**S**	

SD: standard deviation, P: probability, NS: non-significant, S: significant.

There was a significant difference between pre and post treatment values of pain intensity for group (A) ***(Table 7)***. Also, there was a significant difference between pre and post treatment values of pain intensity for group (B) ***(Table 8)***.

Table (7): Comparison of Pain intensity pre and post treatment for group (A)

	Pain intensity (NRS) values

Group (A)	Pre treatment	Post treatment
Median	**6.00**	**2.00**
Range	**3**	**4**
Mood	**7**	4
Mean	**6.13**	**2.33**
SD	**0.74**	**1.23**
Percentage of improvement	**61.99%**	
Z-value	**3.99**	
P-value	**0.000**	
S	**S**	

SD: standard deviation, P: probability, S: significant

Table (8): Comparison of Pain intensity pre and post treatment for group (B)

Group (B)	Pain intensity (NRS) values	
	Pre treatment	**Post treatment**
Median	**6.000**	**5.000**
Range	**4**	**3**
Mean	**6.33**	**5.13**
SD	**1.23**	**0.99**
Percentage of improvement	**18.96%**	
Z-value	**3.96**	
P-value	**0.001**	
S	**S**	

SD: standard deviation, P: probability, S: significant

3. DISCUSSION:

Wheeling and other daily functional activities in patients with spinal cord injury (SCI) result in massive strain on the upper extremity joints and soft tissues when compared to the able-bodied population. Also, the physio-anatomic changes associated with the sudden overuse of upper limbs have demonstrated a link to acute and chronic shoulder pain **[6]**.

One of the most common pathologies associated with shoulder pain is shoulder impingement syndrome, the consequences of which can be incredibly severe for wheelchair users, as it may prevent individuals from being physically active, which can negatively affect their independence and quality of life **[1]**.

Therefore, upper extremity strengthening is considered a critical element of a comprehensive rehabilitation program following SCI. In light of this consideration, exercises should be recommended, with an emphasis on healthy shoulder mechanics **[4]**.

In this study, the patients received conventional physiotherapy program "in the form of therapeutic ultrasound, transcutaneous electrical nerve stimulation (TENS), strengthening exercises for weak shoulder muscles and stretching for tight muscles and shoulder capsule", in addition to circuit resistance training. CRT was done with traditional hand position in the control group while we used the modified hand position in the study group. There was a significant decrease in pain intensity in both groups after treatment with the best results for study group. Also, there was a significant increase in the shoulder ROM in both groups after treatment.

These results agreed with **Pasin et al. [7]** who investigated the efficacy of physical therapy in addition to exercise treatment on pain, shoulder functions, and quality of life in patients with subacromial impingement syndrome (SAIS). They have detected that physical therapy had effective role in terms of pain, quality of life, and shoulder functions. They recommended the application of physical therapy and exercises, which are non-invasive and inexpensive methods without side effects, before invasive treatments particularly in the early stage of SAIS.

Our results also agreed with **Yildirim et al. [5]** and **Levendoğlu et al. [8]** who stated that ultrasound therapy administered to patients with shoulder impingement syndrome resulted in a meaningful increase in range of motion and decrease in pain after treatment.

Also, **Imran et al. [9]** studied the effectiveness of ultrasound therapy in addition to physical therapy and exercises on relief of pain, increase in the range of movements and improvement in muscle power in patients of Shoulder Impingement Syndrome (SIS). They found that the individuals who were subjected to manual and physical exercises therapy of shoulder as well as those who were subjected to ultrasound treatment in addition to manual and exercises therapy had significant improvement after treatment. However, in the latter group, there was the statistically highly significant difference in the degree of range of motion of shoulder joints. There was also observed a significant difference in term of muscle strength grades in impingement syndrome.

Our results also agreed with **Nash et al. [10]** who examined the effects of circuit resistance exercise training (CRT) on middle-aged men with paraplegia. Subjects underwent a 4-month CRT program using alternating resistance maneuvers and high-speed, low-resistance arm exercise. They found that CRT improved muscle strength, endurance, and anaerobic power of middle-aged men with paraplegia and significantly reduced their shoulder pain.

Similarly, **Serra-Añó et al. [11]** reported that, in paraplegic people, isokinetic and isometric shoulder strength were improved with an appropriate shoulder resistance training programme. Furthermore, resistance training increased muscular mass, decreased fat mass in the arms, improved functionality, and decreased shoulder pain.

In this study, the study group showed significant improvement in subacromial joint space, whereas the control group showed no improvement in the subacromial joint space. This means that CRT with traditional hand position may place the shoulder at the risk of mechanical impingement, whereas modification of the hand position during CRT may protect against and improve the mechanical impingement.

In agreement with these results, **Escalante [12]** stated that resistance training result in a large proportion of injuries to the shoulder complex. Even the recreational training population may be predisposed to subacromial impingement syndrome because of some of their specific exercise selections and techniques.

Escalante [12] mentioned several potential explanations for the relatively high rate of injuries to the shoulder complex with resistance training. The amount of mobility allowed by the shoulder joint comes at an exchange of decreased stability. Furthermore, it's hypothesized that most resistance training programs emphasize the strengthening and hypertrophy of large muscle groups such as the pectoralis or deltoids and subsequently neglect the smaller muscle groups such as the scapular stabilizers and rotator cuff that are responsible for stabilizing the scapula and rotating the glenohumeral joint; this may lead to muscular imbalances that may eventually predispose the training participants to shoulder injuries such as subacromial impingement. Additionally, common resistance-training exercises frequently place the shoulder in injury-prone positions such as shoulder abduction with external rotation.

Therefore, biomechanical exercise modifications should be done that will make certain exercises safer and just as effective at achieving the goal to strengthen the upper extremity.

Our results also agreed with **Riek et al. [13]** who stated that the position of the upper extremities during CRT programs may influence the biomechanics at the shoulder joint and is important consideration as mediator of shoulder pain. If these exercise programs place the shoulder at known risks for impingement, then modifications targeting upper extremity positions should be attempted to create a more biomechanically advantageous program with regards to impingement risk.

In this study, the significant increase in the subacromial space of the study group may be explained by altered scapular and glenohumeral kinematics that resulted from the modification of the hand position.

Lawrence et al. [14] agreed with this explanation as they reported that changes in glenohumeral and scapular kinematics are associated with changes in subacromial proximities.

This explanation was also supported by **Savoie et al. [15]** who stated that deficits in performance of scapular and glenohumeral muscles can lead to inadequate kinematics and decreased acromio-humeral distance (AHD). A rehabilitation program based on movement training yielded improvements in symptoms and functional limitations in participants with subacromial pain syndrome. Moreover, it led to an increase of the AHD thus potentially decreasing subacromial compression.

Riek et al. [16] studied the scapular and glenohumeral kinematics during wheelchair-based upper limb CRT exercises to determine whether the CRT exercises with traditional hand position place the shoulder at mechanical impingement risk. They found that the downward press exercise had the highest subacromial mechanical impingement risk "almost half (42.5%) of the exercise was performed in a subacromial impingement range".

Also, **Riek et al. [4]** and **Riek et al. [13]** evaluated three-dimensional (3-D) shoulder kinematic patterns during a wheelchair-based, upper extremity CRT program in individuals with paraplegia to determine if shoulder kinematic patterns can be favourably modified during CRT by altering hand position. They found that the traditional downward press exercise produced the most detrimental kinematic patterns: scapular anterior tilt (-23.8 degrees), scapular internal rotation (46.9 degrees) and glenohumeral internal rotation (-30.6 degrees). Modification of the hand position during the downward press exercise resulted in better kinematics with 4.5 degrees more glenohumeral external rotation and 4.4 degrees more scapular external rotation.

Regarding the overhead pull-down exercise, **Escalante [12]** stated that the underhand (supinated) grip is a better alternative of this exercise. He explained that the supinated grip places the shoulder in a position of relative external rotation which subsequently puts the long head of the biceps tendon under the acromion and rotates the supraspinatus muscle posteriorly away from the acromion. Conversely, the traditional overhand (pronated) grip places the shoulder in a position of relative internal rotation and places the biceps tendon out from under the acromion while positioning the supraspinatus directly under the acromion. It is important to comprehend that if a structure is directly under the acromion, it is potentially at risk for mechanical abrasion if the person has a hooked acromion or if the structure itself is inflamed. Thus, the modified underhand grip may be a good alternative of the overhead pull-down exercise for those recovering from primary shoulder impingement syndrome.

This was also supported by **Riek et al. [4]** and **Riek et al. [13]** who reported that modification of the hand position during the overhead pull-down exercise (from the palm down to the palm up position) resulted in a favourable increase of 18.2 degrees more glenohumeral external rotation and a significant increase in scapular upward rotation than the traditional hand position.

Regarding the horizontal row exercise, **Riek et al. [4]** and **Riek et al. [13]** reported that modification of the hand position during the horizontal row (from the overhand grip to the neutral grip) resulted in a favourable 5-degree increase in scapular upward rotation and a significant increase in glenohumeral external rotation versus the traditional hand position.

Escamilla et al. [17] added that humeral rotation influences impingement during forward flexion. They explained that during internal rotation (as in the overhand grip), the greater tubercle encroaches on the acromion, the coracoacromial ligament, and possibly the coracoid process; however, if the humerus is externally rotated (as in the neutral grip), the greater tubercle is rotated from the acromial arch and can be elevated without impingement.

Regarding the overhead press exercise, **Henriques [18]** and **Aagaard [19]** stated that the traditional overhand (pronated) grip places more stress on the shoulder joint and increases the risk of shoulder impingement especially with a limited ROM in the shoulders. They added that the modified (neutral) grip is preferred and should be used in any pressing motion, either pressing the arms in front or over the head.

Conversely, **Riek et al. [13]** disagreed with these results, as they mentioned that the traditional overhead press (the fully pronated grip) is preferred than the modified overhead press (the neutral grip) with 9.1 degrees more glenohumeral external rotation and 5.5 degrees more scapular external rotation.

Although **Riek et al. [4]** reported that no difference existed in shoulder kinematics between the traditional and the modified hand positions in the chest press exercise. Conversely, **Bleacher and Ellenbecker [20]** stated that the actual grip type affects the subacromial spacing in this exercise. They mentioned that the overhand (fully pronated forearm) grip removes the long head of the biceps from below the acromion because of the internally rotated position of the humerus, but at the same time draw the supraspinatus tendon under the acromion. This overhand position can cause tethering of the supraspinatus tendon if a hooked acromion or primary impingement is present. A neutral hand positioning (forearms resting in neutral pronation and supination) allows for a more anatomically optimal relationship for the tendinous attachments to the anterolateral humeral head.

4. CONCLUSION:

It can be concluded that, the positions in which the shoulder is placed in many CRT exercises make the shoulder joint susceptible to a variety of injuries. Hand position alters shoulder kinematics during CRT. Modifications of hand position during CRT exercises can assist patients in avoiding injuries to the shoulder as well as recovering from shoulder injuries.

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