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SCAPULAR DYSKINESIS IN ASYMPTOMATIC WATER POLO PLAYERS: DOES PREHABILITATION PREVENT NEGATIVE OUTCOMES?

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ABSTRACT

Background: Scapular dyskinesis, or abnormal scapular dynamic control, is a condition which is associated with athletes presenting with shoulder pathology, although it is also found in asymptomatic individuals. Studies differ on whether it is a cause or a symptom of shoulder pain. There is currently no research on whether treating scapular dyskinesis prior to the onset of pain by prehabilitation will stop the progression of pain in asymptomatic water polo players.

Methods: This study was a prospective randomized controlled trial. Twenty-five male water polo players were screened for scapular dyskinesis, and 22 players were included in the study after having a positive finding. The Closed Kinetic Chain Upper Extremity Stability Test (CCKUE), the Functional Throwing Performance Index (FTPI) and the Seated Shot Put Functional Test (SSPT) were used for functional testing, whilst power in abduction, external rotation, and internal rotation was assessed. The Sports section of the DASH score and the Constant score were used. These were obtained at the beginning of the study period. The participants were divided into two groups, the study group, and the control group. The study group underwent daily home stretches (Sleeper's stretch and Pectorals minor stretch) and strengthening exercises (external rotation and forward flexion in a side-lying position, horizontal abduction in the prone position). Follow up with functional testing, strength testing and scores was done at four monthly intervals for one year.

Results: The pain was reported in 3 athletes in the control group compared to 1 in the study group (p=0.59). There was a larger improvement in athletes treated with prehabilitation when assessing external rotation (p=0.01) and internal rotation (p=0.03) when compared to the control group. There was no difference between groups in functional testing, scores and abduction strength.

Conclusions: Prehabilitation in asymptomatic water polo players does not reduce the incidence of shoulder pain. The power of external rotation and internal rotation of the dominant improved more in athletes who performed prehabilitation.

Keywords: Scapular dyskinesis, water polo, prehabilitation, shoulder pain, functional testing.

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INTRODUCTION

Water polo is a team sport which combines swimming a quite a significant amount of overhead shoulder activity. Both activities together make this a very intensive sport and participation in water polo was found to be a risk factor for shoulder pain amongst swimmers [1].

The scapula plays a key role in all shoulder movements. It forms part of the link of the upper limb to the axial skeleton whilst also providing a base from which muscles originate and insert, acting on the humerus and scapula itself to provide shoulder movement. During normal shoulder elevation, the scapula rotates upwards, tilts posteriorly whilst varying internal and external rotation according to the elevation angle [2]. These movements help to maintain a stable ball and socket joint throughout all the movement arc whilst keeping the humeral head in the centre of the glenoid [3].

Scapular dyskinesis is the term used to describe a loss of normal scapular movements without any consideration to the cause of the dyskinesis [3]. It is a common finding in athletes presenting with shoulder pain of any cause [4]. Scapular dyskinesis is also seen secondary to weakness or stiffness of muscles controlling scapular motion namely pectoralis minor, short head of biceps [5], serratus anterior or trapezius [6]. Other possible causes of scapular dyskinesis include impingement, rotator cuff disease, superior labral tears acromioclavicular joint pathologies and multidirectional instability [3]. A decrease in sub-acromial space was found in swimmers, and this was related to their training load. This would increase the risk of impingement which in turn may cause shoulder pain which is related to scapular dyskinesis [7].

Scapular dyskinesis was found to be higher after a training session in asymptomatic swimmers [8]. This would point to the possibility of muscular weakness or imbalance as a cause for the dyskinesis. Whilst scapular dyskinesis alone is not a pathological finding; it is still a matter of discussion whether scapular dyskinesis is a direct cause for shoulder pain. The management of internal impingement and scapular dyskinesis is to try to strengthen the periscapular muscles and improve scapular posture mostly by focussing on the trapezius muscle, rotator cuff muscles and anterior and posterior capsular stretching to achieve scapular balance [6].

Prevention techniques and prehabilitation were found to reduce the injury risk and severity in rugby players [9] whilst this was also true for lower limb injuries in football when neuromuscular training was performed [10,11]. There is currently no research about the prevention of shoulder pain in swimmers or water polo players with asymptomatic scapular dyskinesis.

This study aimed to assess if there is a progression to pain in asymptomatic water polo players with scapular dyskinesis and if scapular prehabilitation prevents progression to pain. The secondary aim of the study was to evaluate if scapular prehabilitation improves the functional status of the upper limb.

METHODS AND MATERIALS

This study was a conducted as a prospective randomized controlled trial after being approved by the Research Ethics Approval for Health (REACH) of the University of Bath. The study commenced in May 2016, and this coincided with the start of the pre-season training for the 2016 summer Malta water polo league. Twenty-five male, semi-professional water polo players, were screened for scapular dyskinesis from a single water polo club (age 23.1 ± 3.5 years). This was done after getting consent from the athletes and enquiring about any current or previous shoulder pain. The inclusion and exclusion criteria are shown in Table 1.

Inclusion Criteria	Exclusion Criteria
Male	Bilateral Shoulder Dyskinesis
Unilateral Scapular Dyskinesis	Previous shoulder pain stopping them from training/playing for three consecutive days within one year
Active water polo player	Previous or current major shoulder trauma
16 years of age and older	Current rehabilitation from a shoulder injury
No previous shoulder surgery	

Table 1: Inclusion and Exclusion Criteria

Scapular Dyskinesis

Scapular dyskinesis was studied extensively and classified into four types [12,13]. Type I dyskinesis is characterized by the prominence of the inferior medial angle of the scapula with the excessive anterior tilting of the whole of the scapula. Type II is associated with internal rotation of the scapula thus making the whole of the medial border prominent. Type III dyskinesis is defined by having a superior migration of the scapula with the prominence of the superior scapular border. Type IV is considered normal with no asymmetries being seen.

Screening for dyskinesis was done by asking the athletes to abduct in the scapular plane whilst holding a 1 kg weight in their hands and examining and filming their scapulae from behind [14].

This examination was done after a routine evening training session [8,15]. Athletes who had a positive examination for any type of scapular dyskinesis detailed above were included in the study.

Scoring

The sports section of the Disabilities of the Arm, Shoulder, and Hand (DASH) [16] and the Constant scores [17-19] were used as a method of scoring the athletes. The DASH score comprises of four questions which are then scored depending on the answer. It is graded from 0 to 100 with 0 being the best score. The Constant score is divided into two sections. The first section is a questionnaire and the second question being an objective examination of the athlete. It is graded from 0 to 100 with 100 being the best score.

Strength Testing

The power of abduction, external rotation and internal rotation of both shoulders was assessed using a spring balance with an adjustable strap [20]. The abduction was carried out in the scapular plane with the elbow in full extension and the strap of the spring balance looped around the distal arm with resistance provided by the ipsilateral foot of the athlete. Internal and external rotation testing was carried out starting with the arm in 0^o of abduction and neutral rotation and the elbow in 90^o of flexion. The spring balance attached to a fixed point on a wall and the strap looped around the wrist of the examined arm. Three attempts of each movement were carried out, and the best measurement seen on the spring balance was taken as the final measurement.

Functional Testing

Functional testing was done using the Closed Kinetic Chain Upper Extremity Stability Test (CCKUE) [21], the Functional Throwing Performance Index (FTPI) [22] and the Seated Shot Put Functional Test (SSPT) [23,24]. The CCKUE test was done by placing two pieces of tapes on the floor 90 cm apart. The subject was asked to assume a push-up position with one hand on each piece of tape and the body as straight as possible. The test involves removing one hand (starting with either hand), touching the opposite hand, replacing the hand on the original tape and then repeating this with the other hand. One test consisted of the continual alternating sequence as described for 15 seconds. 1 submaximal try was attempted after which 1-minute rest was given to then attempt three maximal-effort attempts with a 1-minute break between attempts. The subjects tried to achieve as many touches as possible during each test, and the average of the three tests was taken.

The FTPI was carried out using a 30cm x 30cm box marked on a wall at a height 1.22m from the ground and the subject standing 4.5m away from the wall. The test involved throwing a tennis ball as accurately as possible in the target box using a natural throwing motion. One test involved the subject throwing the ball, catching the ball in its rebound off the wall and as many throws as possible over 30 seconds. One submaximal test was allowed for acclimatization of the technique, and then three maximal-effort tests were done with a 1-minute break in between the tests. The FTPI was calculated as the number of correct throws within the target divided by the total number of throws, and an average of the three tests was taken as the final result.

The SSPT was done with the subject sitting down on the floor with his back to the wall and the hips, knee, and ankles in a straight line. A 3kg medicine ball was used, and the subjects were asked not to 'throw' the ball in an overhead baseball-type fashion, but to use a shot-put throwing method. Three sub-maximal tries were attempted to ensure good throw technique, and this was followed by a 2-minute rest. Three maximal-effort puts were then attempted, and the distance of the throw was calculated from the heel of the subject to where the ball first struck the ground with the best distance used for the study.

The athletes were then divided into two groups; the control group and the study group. No added intervention was planned in the control group whilst stretches and exercises were advised to the study group. These included 1) The Sleeper's Stretch to the posterior capsule [25], 2) Stretching of Pectoralis Minor [26], 3) External rotation in Side Lying position, 4) Forward Flexion in Side Lying Position and 5) Horizontal Abduction in Prone Position [6]. The athletes in the study group were encouraged to perform three 30-second sets of both the sleeper stretch and the pectoralis minor stretch once a day. 1kg dumbbells were used in the latter three interventions with the subjects advised to perform 30 repetitions of each exercise daily. These were only performed for the dominant arm in the side-lying exercises whilst both shoulders were exercised in the exercise done in the prone position (Table 2) (Figure 1).

Exercise	Material	Description
Sleeper's Stretch	Nil used	Subject lying on the side with dominant shoulder below, thorax straight and hips flexed. The dominant shoulder and elbow were both flexed to 90o. The non-dominant hand grasped the dominant wrist and gently turned the shoulder into the internal rotation until a stretch, but no pain was felt.
Pectoralis minor Stretch	Vertical Wall	Subject standing with the dominant shoulder abducted and externally rotated to 90o, elbow flexed to 90o and the palm placed on a flat vertical planar surface. The subject then rotated the trunk away from the elevated arm, increasing horizontal abduction of that arm until a stretch was felt in the anterior chest.
Side Lying External Rotation	Dumbbell, Towel	Subject lying on the side with the dominant shoulder above, in a neutral position and elbow, flexed to 90o; subject performed external rotation of the shoulder (towel between trunk and elbow to avoid compensatory movements)
Side Lying Forward Flexion	Dumbbell	Subject lying on the side with the dominant shoulder above, in a neutral position and 0o of flexion with the elbow fully extended; subject forward flexed shoulder in a horizontal plane to 135o
Horizontal Abduction	Dumbbells	Subject lying prone with shoulders in 90o of forward flexion; subject performs horizontal abduction until arm is parallel to the floor

Table 2: Description of the five interventions performed by the Study group

Figure 1: a. Sleeper's Stretch b. Side Lying external rotation c. Side-lying forward flexion d. Horizontal abduction

Shoulder pain precluding the athlete from playing or training for three consecutive days was considered as a positive finding fulfilling the primary aim of the study. These athletes were subsequently removed from the study and rehabilitation started accordingly. The DASH score, Constant Score, CCKUE test, FTPI, SSPT and power of abduction, external rotation and internal rotation were repeated at four monthly intervals in the remaining pain-free athletes for a total follow up 12 months from the start of the study.

Statistical Analysis

Statistical analyses were conducted using IBM SPSS statistics version 23.0 for Windows. The data were tested for normality by using the Shapiro Wilk test and was found to be normally distributed with normal variances. Independent t-test and Chi-square tests were used to check significance. For all analyses, a P-value of 0.05 or less was considered to be statistically significant. This study was approved by the Research Ethics Approval for Health (REACH) of the University of Bath.

RESULTS

Twenty-five athletes accepted to take part in the study. Of these, twenty-three had a positive finding of scapular dyskinesis after examination. Twelve athletes were included in the study group. One athlete in the study group had a traumatic shoulder dislocation during the study period and was thus excluded from the study leaving 11 athletes in each study arm (Figure 2).

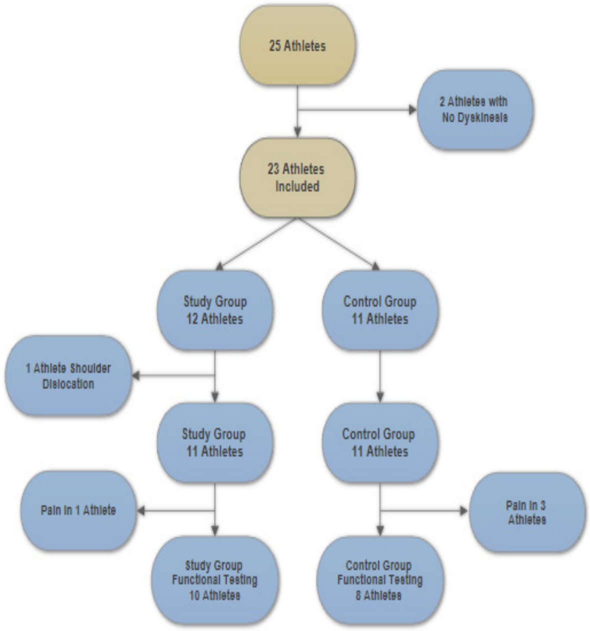

Figure 2**:** Screening, Enrolment, Random Assignment and Follow-up of the Study participants

All athletes were male with the mean age being 23.11 years (range 18 years – 32 years). Most athletes where right hand dominant (82%) with most dyskinesis occurring at the dominant shoulder (82%). Nine athletes reported that they had previous shoulder pain which had stopped them from training or playing however this was more than one year from the date of the start of the study. The baseline characteristics of the two groups are shown in Table 3. There were no significant differences in demographic variables as well as in the functional and power assessments between athletes in the study group and the athletes in the control group at the outset of the study.

Variable	Study Group (n=11)	Control Group (n=11)	P value
Age - years	23.3±4.02	23.1±3.23	0.92
Right Hand Dominance – no. (%)	9(81)	9(81)	1
Site of Dyskinesis on Dominant Side – no. (%)	9(81)	9(81)	1
Previous Shoulder Pain – no. (%)	5(45)	4(36)	1
Functional Assessment			
Dash Score	1.14±2.55	0±0	0.22
Constant Score	99.73±0.9	100±0	0.33
CCKUE reps - no	23±2.31	23±2.65	1
FTPI - %	56.1±10.1	57.6±4.06	0.65
SSPT measurement – cms	461.8±54.55	452.7±28.31	0.63
Power Assessment			
Abduction power dominant arm - kgs	10.64±2.50	11.09±1.70	0.62
Abduction power non-dominant arm – kgs	10.63±2.20	11.09±1.20	0.33
External rotation power dominant arm - kgs	9.18±1.54	9.18±0.75	1
External rotation power non-dominant arm - kgs	8.55±1.21	8.73±0.78	0.68

Internal rotation power dominant arm - kgs	10±1.34	9.55±0.52	0.31
Internal rotation power non-dominant arm - kgs	9.73±1.42	9.27±0.78	0.36

Table 3: Demographic comparison of subjects in both groups*

*Plus-minus values are means ± SD

During the study period, three athletes in the control group reported pain in the shoulder displaying dyskinesis, whilst one athlete in the study group presented with shoulder pain (p=0.59). These athletes were treated accordingly, and thus subsequent functional testing was stopped after presenting with pain and was done in the remaining eighteen athletes.

Functional assessment was done by using the sports section of the DASH score and the Constant score. During the first interview, two athletes in the study group reported mild difficulty in performing their normal technique in the previous week. This was due to an unrelated hand injury. This resulted in a mean DASH score of 1.14 in the study group at the first encounter. The difference in the groups was not statistically significant. Subsequently, all athletes in both groups reported no problems in their performance in all encounters. This resulted in a DASH score of 0 in both groups in all sessions. The Constant score yielded comparable results with a score of 100 being reported in all athletes of both groups in all encounters.

Table 4 shows functional testing in both groups. Both groups showed an improvement in their performance in all the three tests throughout the study. The difference between the groups seen in the number of repetitions of the CCKUE test, the FTPI score, and the SSPT distance was not statistically significant throughout the study.

Encounter	**CCKUE (reps)**		**p Value**	**FTPI(%)**		**p Value**	**SSPT(cms)**		**p Value**
	Study	Control		Study	Control		Study	Control	
Index	23.1 ±2.4	23±3	**1**	56.1 ±10.7	57.2 ±3.6	**0.65**	465 ±56	451 ±16	**0.63**
4 months	23.3 ±1.7	23.4 ±2.5	**0.94**	57.9 ±7.1	60.7 ±6.3	**0.38**	464 ±54	454 ±17	**0.69**
8 months	23.6 ±1.6	23.3 ±2.2	**0.70**	58.9 ±4.9	60 ±3.7	**0.61**	468 ±49	455 ±19	**0.49**
12 months	24.8 ±1.5	23.6 ±1.9	0.17	59.8 ±4.1	61.7 ±6.7	0.46	474 ±50	458 ±14	0.42

Table 4: Functional Assessment of both groups throughout the study*

*Plus-minus values are means ± SD

Tables 5 & 6 show power testing of both upper limbs with Table 5 showing the results of the dominant arm and Table 6 showing the results of the non-dominant arm. The mean power of external rotation and internal rotation in the dominant arm was greater than in the non-dominant arm. Abduction power showed similar measurements in both arms.

Encounter	**Abduction (kg)**		**p Value**	**External Rotation (kg)**		**p Value**	**Internal Rotation (kg)**		**p Value**
	Study	Control		Study	Control		Study	Control	
Index	10.7 ±2.6	11.2 ±1.8	**0.62**	9.1 ±1.6	9.1 ±0.8	**1**	10 ±1.4	9.5 ±0.4	**0.31**
4 months	11.3 ±2.2	11.7 ±1.6	**0.63**	10 ±1.8	10 ±1.4	**0.87**	10.1 ±1	9.9 ±1	**0.63**
8 months	12.8 ±1.2	11.6 ±0.9	**0.39**	10.1 ±1.9	10.1 ±1.3	**0.54**	11.1 ±1.4	10.4 ±1.1	**0.23**
12 months	12.8 ±1.2	11.5 ±1.7	0.07	10.6 ±1.2	10.6 ±1	0.01^	11.3 ±1.3	10.1 ±0.8	0.03^

Table 5: Power in the dominant arm in both groups*

*Plus-minus values are means ± SD

^Statistically significant

Encounter	**Abduction (kg)**		**p Value**	**External Rotation (kg)**		**p Value**	**Internal Rotation (kg)**		**p Value**
	Study	Control		Study	Control		Study	Control	
Index	10.7 ±2.3	11.2 ±1.2	**0.33**	8.4 ±1.2	8.6 ±0.7	**0.68**	9.7±1.5	9.1±0.8	**0.36**
4 months	11.2 ±2	11.5 ±0.9	**0.71**	8.8 ±0.8	9 ±0.8	**0.59**	9.7±1.1	9.5±0.9	**0.68**
8 months	12.7 ±1.6	11.6 ±1.2	**0.12**	9.4 ±1	8.6 ±0.5	**0.58**	10.3±1.5	9.5±0.5	**0.17**
12 months	12.8 ±1.5	12.1 ±1.2	0.32	8.8 ±0.9	9 ±0.8	0.63	9.9±1.2	9.1±0.8	0.14

Table 6: Power in the non-dominant arm in both groups*

*Plus-minus values are means ± SDfigure

When focussing on the dominant arm, the global increase in power in all three planes of movement tested was observed throughout the study. The difference in the power of abduction, external rotation and internal rotation between the two groups at the end of the study was 1.3kgs, 1.5kgs, and 1.2kgs respectively. This was found to be statistically significant in external rotation (p=0.01) and internal rotation (p=0.03) but not in abduction (p=0.07) although this was close to the cut-off statistical significance of 0.05.

In the non-dominant arm, there was minimal difference in the mean power of external and internal rotation throughout the study with a small improvement in abduction which is comparable to the increase seen in the study group. All differences seen in the three planes of movement between the two groups in the non-dominant arm were not found to be statistically significant.

DISCUSSION

To the author's knowledge, this study was the first one of its kind to research injury prevention in water polo players who displayed asymptomatic scapular dyskinesis by comparing normal training with the addition of prehabilitation to the normal training. Although scapular dyskinesis is not considered to be an injury or a pathological entity, there is substantial evidence of scapular kinematic changes in athletes presenting with shoulder pain [4,27].

Several studies observed athletes with asymptomatic dyskinesis to try to predict the onset of shoulder pain with the presence of dyskinesis. These had variable results with some of the studies showing an association of scapular dyskinesis with shoulder pain [13,28] whilst other studies failed to show this relationship [29,30]. These studies were done in athletes subjected to overhead activities during their sports and included rugby, baseball, volleyball, tennis and badminton players. None of the studies included swimmers or water polo players.

No significant difference could be demonstrated in the occurrence of pain if prehabilitation is carried out or not, although there was a higher number of athletes presenting with pain in the control group. Therefore, the hypothesis that prehabilitation of athletes with asymptomatic scapular dyskinesis prevents pain was rejected in this study.

There are some interpretations for this observation. First is that scapular dyskinesis, or alteration of scapular motion during overhead activity is not a leading factor to a shoulder injury in water polo players. This alteration of movement may be a positive factor in water polo players and thus not at all pathological. Swimmers were noted to have a more forward shoulder posture with a protracted scapula when compared to athletes not having overhead activity as part of their sport such as football players and long-distance runners [7]. A strong pectoralis major muscle is desirable, as this muscle is important in forward propulsion in swimming and in internally rotating the shoulder during throwing. This forward posture of the scapula would be secondary to a stronger pull by the pectoralis major muscle and thus shifts the whole scapula forward causing the visible dyskinesis. This is thought to increase the risk of impingement of the humeral head on the acromion [31].

However, in a different study, McKenna et. Al., 2011 demonstrated that scapular position was not found to affect humeral position in swimmers. This may explain that a protracted forward scapula in swimmers and water polo players is necessary, as strong anterior muscles are required, but unlikely to cause impingement.

A second interpretation is that scapular dyskinesis is only a part of a multifactorial pathological process. Other factors, either in synchrony with scapular dyskinesis or independent of it, may be important in the etiology of pain in these athletes [31]. These causes may include the range of motion of the shoulder and ligament laxity of the glenohumeral joint. Whilst McMaster et al., 1998, found a positive correlation between shoulder laxity and shoulder pain in swimmers, this finding is not consistent in all studies. Sein et al., 2010 found only a minimal association of glenohumeral laxity with shoulder pain in swimmers. Using MRI, the same team demonstrated that the cause of pain was supraspinatus tendinopathy.

Shoulder range of motion is also implicated as potential causation of shoulder pain, however, studies report inconsistent results. Several studies found decreased internal rotation range of motion [1,32], or a high (>100 ^{o}) or low (<93^{o}) external rotation range of motion [32,33] at the shoulder to be associated with shoulder pain. However other studies fail to show this association [34,35].

These findings all suggest that the causation of shoulder pain in swimmers and water polo athletes is still unclear with different causative factors being implicated. Treating scapular dyskinesis independently to these other factors may be the reason why no change was seen in this study between the two groups.

Another interpretation could be that the time taken for an athlete with scapular dyskinesis to develop pain may be more than one year. To the author's best knowledge there is no research indicating the time taken from the development of scapular dyskinesis to the potential onset of pain. Thus, one may suggest that longer longitudinal studies should be undertaken to try to answer this question.

Functional Tests

The secondary aim of the study was to assess if prehabilitation affected the function of the shoulder. Smith et al., 2006 found that scapular position would affect the power generated by the shoulder. A more particular observation was that if the scapula is protracted forward, the shoulder will generate 13% to 24% less internal rotation power when compared to having a neutral scapula. A general improvement in all three functional tests in both groups was noticed. Given that both groups improved, this observation may be attributed to the increase in training intensity as the study progressed. The study group showed a larger improvement in strength based tests (CCKUE and SSPT) when compared to the control group, although this difference was not statistically significant.

Tucci et al., 2014 demonstrated that the CCKUE test is a reliable tool in the functional assessment of the upper extremity in upper extremity sport specific athletes. The same study concluded that an improvement of the CCKUE test by at least three repetitions in males signifies an improvement, however there is no mention of which sports were included. This study showed a mean improvement of 1.7 and 0.6 repetitions in the study group and control group respectively. Thus, although there was a larger improvement in the study group, prehabilitation did not help to improve the functional status of the limb to a significant effect as measured by the CCKUE test.

The SSPT was found to correlate well with upper body power in male students [36]. Similar to the CCKUE test, the slightly larger improvement in the study group as compared to the control group (+9 and +7 respectively) was not significant.

The study group underwent stretches to the pectoralis minor muscle, which is a contributor to forward scapular protraction. This may have helped the athletes in the study group to decrease their amount of scapular forward protraction and thus generate more power in the affected shoulder [37]. This would explain the larger improvement in strength based tests in the study group over the control group.

Power Tests

In the study group, both external rotation and internal rotation power (+1.5kgs and +1.3kgs respectively) showed greater improvement when compared to the control group (0kgs and +0.6kgs respectively) in the dominant arm. This was the only significant improvement which was observed in this study. This finding agrees with the findings of Smith et al., 2006, that internal rotation power improves with a decrease in scapular forward protraction. That study also showed that scapular protraction does not affect external rotation power when the test starts with the shoulder in internal rotation or mid-range. This differs from what was found during this study as external rotation power testing was done starting from mid-range of shoulder movement.

The scapula needs to offer a stable base for scapular muscles to work effectively. The Posterior tightness was found to the cause of scapular protraction in baseball players [38]. With tight structures around the shoulder, this base would not be balanced, and thus the scapula may slide anteriorly or posteriorly. Hence tightness is thought to be a reason for the dyskinesis. As postulated previously, this may cause the scapular muscles, to start working from an unfavorable position, altering the lever arm of these muscles which in turn would decrease the power generated by these muscles. Stretching and strengthening structures controlling scapular positioning may restore this balance, improve the muscles' lever arm and thus the increasing the power generated.

Abduction is also a movement which is started by a scapular muscle, more particular the supraspinatus. This muscle was not targeted in the prehabilitation exercises and stretches, and this would explain why no difference was seen between the two groups.

Scores

Two scoring systems were used to try to track improvement or deterioration in the athletes. Both scores failed to detect any changes in both groups successfully. The sports section of the DASH score would only sense any deterioration if there were pain severe enough to stop the athlete from their normal training routine or technique. The Constant score also failed to detect any changes throughout the study on both groups as all athletes were capable of performing their normal activities of daily living and had full shoulder range of movement on repeated examinations. This shows that both scores are not adequate to assess for any change of shoulder function in asymptomatic athletes. Further research is warranted to create new scoring systems which may provide this information. Strength testing should be included in these scores as this was the testing criterion which was found to be most significantly changed.

Strengths and Limitations

The strength of the study is in the fact that all athletes, bar one, recruited at the beginning of the study were able to finish the study. Only one athlete was lost due to a traumatic shoulder dislocation unrelated to his water polo activities. All athletes were assessed a total of four times for one year. This incorporated a pre-season for the summer league which is the main water polo league, the summer league which then continues to winter league after a short break. Thus, training intensity fluctuated slightly throughout the study, but training continued all throughout the study.

Several study limitations need to be mentioned. Although all athletes were followed up successfully for one year, the progression of pain in athletes displaying dyskinesis is still unclear. Increasing the study period further may expose any athletes who may eventually develop pain after the study period, although as discussed above, further studies are needed to answer this question. All athletes included were semi-professional athletes. However, the full-time occupation of these athletes was not taken into consideration. All athletes selected were from the same water polo club, and whilst this ensured that all players had the same training regime and intensity, it may have been beneficial to include other water polo clubs to both increases the number of athletes included and tested the hypothesis with different training methods. The final limitation to mention is the fact that all types of dyskinesis were included in the same cohort of athletes. Thus there may be types of dyskinesis which may benefit more from prehabilitation than other types. This is an area for future research.

CONCLUSIONS

Prehabilitation in water polo players who display asymptomatic shoulder dyskinesis does not make any difference in the prevention of onset of shoulder pain within a one-year period. Prehabilitation improves the power of external rotation and internal rotation in the dominant shoulder. Further studies need to be undertaken to develop a scoring system to track the progression of shoulder function in water polo players.

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