

Anatomical Shoulder Movement Strength Imbalance Among Water Polo Overhead Athletes

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ARTICLE INFO

Article history

Received: January 07, 2019

Accepted: March 27, 2019

Published: April 30, 2019

Volume: 7 Issue: 2

Conflicts of interest: None

Funding: None

ABSTRACT

Background: The game of water polo has become more familiar to all the athletes and coaches as the time has passed. It has been played as a sport for more than a century. Although anatomical shoulder movement strength balance is a crucial factor in overhead throwers' performance, it has not been studied extensively in the previous research. **Objective:** This study examined shoulder movement imbalance in bilateral and dominant anterior-posterior shoulder among 42 elite water polo players in Malaysia. **Method:** The t-test analyses of data obtained through several tests proved that water polo players had statistically significant difference between their right hand anatomical shoulder movement strength and their left hand anatomical shoulder movement strength in all eight shoulder movements, i.e. Flexion, Extension, Abduction, Adduction, Horizontal Adduction, Horizontal Abduction, Rotation and External Rotation. **Results:** The results of this study showed that there are significant differences of anatomical shoulder movement strength in both bilateral and Anterior-posterior shoulder movement among water polo players. The statistics results for bilateral shoulder movement of Flexion ($t= 136.09$ and $p<.001$), Extension ($t= 110.92$ and $p<.001$), Abduction ($t= 121.89$ and $p<.001$), Adduction ($t= 101.47$ and $p<.001$), Horizontal Adduction ($t= 92.3$ and $p<.001$), Horizontal Abduction ($t= 95.6$ and $p<.001$), Internal rotations ($t= 109.6$ and $p<.001$) and External rotations ($t= 102.18$ and $p<.001$) showed the p-value to be less than 0.05 for all variables of the test. The result of paired samples t-test showed there is a statistically significant difference between the mean of bilateral anatomical shoulder movement strength among water polo players. **Conclusion:** These findings suggest that coaches and players should take into account the shoulder movement strength imbalance in their trainings and design specific training programs to improve overhead throwers' shoulder movement strength balance and hence their throwing performance in sports such as water polo.

Key words: Isokinetic Strength, Shoulder Rotators, Sports Injuries, Overhead Thrower, Water Polo

INTRODUCTION

Water polo is a kind of complex team sport that involves the high and low intensity activities such as jumping up from the water, shooting, swimming and passing the ball during one game period. In water polo the players must face their challengers through contacting, blocking and pushing (Fergat et al., 2011; Garbolewski & Starosta, 2002; Nekooei, Majlesi, Sharifi, Fadilah, & Nekouei, 2016; Smith, 1998; Stevens, Brown, Coburn, & Spiering, 2011; Wende, 2005). The daily concerns of all water polo coaches in the world are thinking and optimization to determine the capacity of specific physical structure of water polo players and because of this concern they prefer to choose faster and stronger play-

ers. But the important part of throwing performance is not only focusing on power. On the other hand, the shoulder imbalance and limited internal/external Glenohumeral rotations may play an important role in throwing performance (Wang, Macfarlane, & Cochrane, 2000). Beginning with the ancient Greeks, coaches and athletes have always sought new methods and techniques to improve speed and strength. Speed and strength combined is power, and power is essential to the performance of many sport skills that involve throwing performance. Although specific exercises designed to enhance power have been around for some time, it has only been in the last decade that a system has emerged which emphasizes this type of training. Furthermore, all of these trainings are only

designed for dominant hand of overhead throwers and need a specific place and equipment, so these kinds of trainings may lead water polo players to have bilateral anatomical shoulder movement strength imbalance. The anatomical shoulder movement strength balance is one of the most important factors in having high speed and accurate throwing during the throwing procedure. The factors such as flexion and extension of shoulder, abduction and adduction of the shoulder and the internal and external rotations of the shoulder are very important for having a great shooting performance but having imbalance between these movements reduces the ball velocity and accuracy in water polo shooting procedure (Clements, Ginn, & Henley, 2001; Hadzic, Sattler, Veselko, Markovic, & Dervisevic, 2014). However, nowadays almost all studies are on dominant hand throwing velocity and accuracy, with a focus only on the result of shooting and not the process involved in the shooting performance. In fact, these studies only focus on the dominant hand of players because they believe that the left hand is only used for controlling the body and trading water and does not play any role in shooting procedure while players throw the ball with their right hand. Coaches around the world have a similar goal for their water polo players; all of them try to find a way to improve the throwing performance of their players. Therefore, they design and plan their training protocols to reach this goal, and then they only focus on dominant throwing hand of players to improve their throwing performance. Moreover, the rules of water polo do not allow the players to bring their two hands up for defense and making shots during the game time. Thus, water polo players always have to throw, defend and train using their dominant hand, and this makes them one-sided players. Being one-sided, exclusive of leading players to have injuries and problems such as back pain, shoulder pain and limited internal/external Glenohumeral rotations, will lead to shoulder imbalance and this anatomical shoulder movement strength imbalance will have a negative effect on players' performance (Aliprandi et al., 2013; Wang et al., 2000).

The most important problem that all overhead throwers face is shoulder movement strength imbalance such as limited internal/external Glenohumeral rotations (Kibler, Sciascia, & Moore, 2012) and this problem may affect throwing performance. The nature of water polo and the rules of the game make all water polo players one-sided players, so all of them only focus on improving their dominant hand, exposing them to the anatomical shoulder movement strength imbalance position. The anatomical shoulder movement strength imbalance can lead players to get scoliosis and limited internal/external Glenohumeral rotations and these abnormalities lead all overhead players to suffer from back pain and other problems (Aliprandi et al., 2013; Pascal Edouard et al., 2013; L, 2014; Mota & Ribeiro, 2012). There are many studies about water polo performance and trainings to improve throwing accuracy and velocity, but still there is a gap in the literature about the bilateral and anterior-posterior anatomical shoulder movement strength imbalance among water polo players. Thus, current study aimed to examine whether water polo players have significantly different in their dominant and non-dominant anatomical shoulder movement strength

and internal/external Glenohumeral rotations strength. The relevant hypotheses areas in this research are as follow, there are significant differences between anterior and posterior anatomical shoulder movement strength among water polo players and the second hypothesis of the research is there are significant differences between bilateral anatomical shoulder movement strength among all players.

METHOD

Participants and Design

The participants of this study were 45 water polo players with the age range of 15-21 years who were members of a Malaysian water polo elite club for a minimum of three years. They played on a team that was ranked as one of the first three teams of the Commonwealth Championship Malaysia. The design of this study was Cross-sectional study design who researcher selects participants base on purposive sampling method. Participants also fill the consent form and The Physical Activity Readiness Questionnaire (PAR-Q) before participating in this study. Base on PAR-Q results, participants who had shoulder pain or health issue were exclude from this study. They underwent 8 shoulder movement strength tests for the purpose of this study. Ethical approval from an appropriate committee of University Putra Malaysia and consent form was obtained from participants before beginning this research.

Procedure

The study was done at the beginning of the general preparation training of water polo players, following the competitive season. The general preparation training included 6 to 10 hours of training in a week with a low intensity, high volume build-up (60 to 70%) maximum heart rate. It also included 6 hours per week of high intensity, low volume (85%) maximum heart rate training. The researcher familiarized all the participants with the testing procedure before testing. The participants were asked to avoid strenuous exercise for forty-eight hours and refrain from intake of food and caffeine two hours before assessment. In order to avoid any circadian rhythm effects, the tests for all participants were completed at the same time of the day. The tests was done using MicroFET© handheld dynamometer (HHD) at the swimming pool area (MicroFET 2, Hoggan Health Industries Inc., Biometrics, The Netherlands). The wireless microFET2 Digital Handheld Evaluation and Testing (FET) device is accurate and portable that has been specifically designed for taking reliable, objective, and quantifiable measurements of muscle testing. The test was done for both dominant and non-dominant hand of water polo players. For more accuracy of testing all participants were tested after doing the specific warm up compiled by the researcher and each test was conducted 3 times. For measuring the strength of anatomical shoulder movement, 8 shoulder movements such as flexion, extension, abduction, adduction, horizontal abduction, horizontal adduction, internal rotation and external rotations of dominant and non-dominant shoulder were measured. In this

test the participants were asked to lay in prone position on the treatment table with their legs straight and researcher were measured their anatomical shoulder movement strength in a hand position of 90-degree angles with their body.

Statistical Analysis

The statistics used to reach the objectives of the study and test their relevant hypotheses was independent samples t-test. This statistic is a parametric test which enables a researcher to compare the values on some continuous variables for two groups of data (Watson, 2001). For reaching this aim, researcher ran Independent sample t-test on statistical package for social sciences-21 (SPSS 21) software for two group of data which was dominant and non-dominant hand of water polo players with Alpha level of 0.05 was used to determine statistical significance in all comparisons. Before using independent samples t-test normality assumptions were checked and all the data were normal.

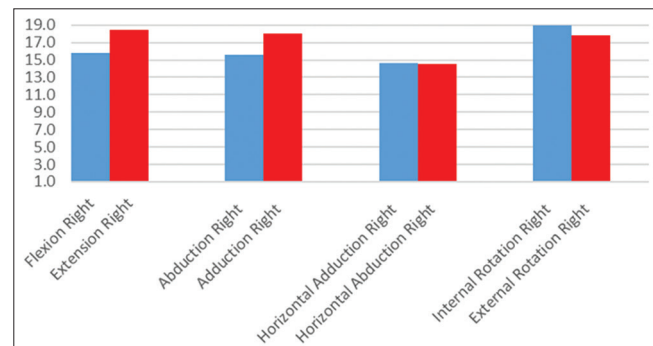
RESULTS

Comparison of Anatomical Shoulder Movement Strength between Anterior-posterior

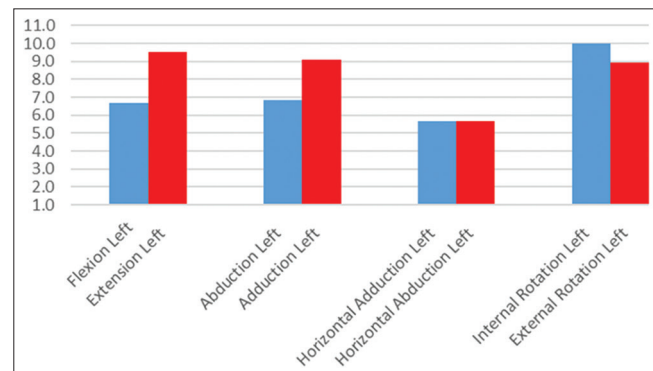
The independent samples t-test was conducted to test the differences between mean scores of anterior-posterior shoulder strength of water polo players. As displayed in Table 1, P-value for flexion vs extension, abduction vs. adduction and internal rotation vs. external rotation were <0.001 in both left and right shoulder, meaning that the hypothesis one of this study is supported and there is a significant difference between anterior-posterior shoulder strength on these variables among water polo players. However, for horizontal adduction vs horizontal abduction shoulder strength, P-value was 0.238 for the right shoulder and p-value was 0.904 for the left shoulder, suggesting that there was no significant

difference between horizontal adduction and horizontal abduction in both left and right shoulder.

In Graph 1 and Graph 2 all of the Anterior anatomical shoulder movement strength are showed in Blue color and all of the posterior anatomical shoulder movement strength are showed in Red color. As displayed in Graph 1 and Graph 2, flexion and abduction movement strength are weaker than extension and adduction movement strength



Graph 1. Right Hand Anterior-posterior



Graph 2. Left Hand Anterior-posterior

Table 1. Comparison of Anatomical Shoulder Movement Strength between Anterior-posterior

	Mean	SD	T value	P value	
Flexion. Right	15.79	2.3	-19.92	<0.001	FL<EX
Extension. Right	18.41	2.1			
Flexion. Left	6.679	2.48	-21.99	<0.001	FL<EX
Extension. Left	9.519	2.42			
Abduction. Right	15.61	2.23	-22.18	<0.001	ABD<ADD
Adduction. Right	18.07	2.39			
Abduction. Left	6.857	2.44	-16.3	<0.001	ABD<ADD
Adduction. Left	9.064	2.92			
Horizontal. Adduction. Right	14.68	1.56	1.197	0.238	
Horizontal. Abduction. Right	14.57	1.67			
Horizontal. Adduction. Left	5.655	2.08	0.121	0.904	
Horizontal. Abduction. Left	5.643	2.21			
Internal Rotation. Right	18.92	2.46	9.983	<0.001	IR<EXR
External Rotation. Right	17.84	2.18			
Internal Rotation. Left	10.02	2.95	9.955	<0.001	IR<EXR
External Rotation. Left	8.912	2.69			

FL=flexion, EX=Extension, ABD=Abduction, ADD=Adduction, IR=Internal Rotation, EXR=External rotation

in both right and left hands. It shows that posterior muscles are weaker than anterior muscles among water polo players. In addition, internal rotation of both hands was stronger than their external rotation among water polo players.

The results of this study show that there are significant differences in shoulder movement strength among water polo players. The results also indicate that water polo players have significant anterior–posterior shoulder movement imbalance due to their kind of sport. On the other hand, water polo players have stronger anterior shoulder muscles than posterior shoulder muscles and this leads to anterior-posterior shoulder movement imbalance among the players.

Comparison of Bilateral Anatomical Shoulder Movement Strength

In order to determine if there was a significant difference between bilateral (dominant and non-dominant) anatomical shoulder movement strength among all water polo players, paired samples t-test analyses of the data were conducted as well. As summarized in Table 2, the statistics of pair 1 ($t= 136.09$ and $p<.001$), pair 2 ($t= 110.92$ and $p<.001$), pair 3 ($t= 121.89$ and $p<.001$), pair 4 ($t= 101.47$ and $p<.001$), pair 5 ($t= 92.3$ and $p<.001$), pair 6 ($t= 95.6$ and $p<.001$), pair 7 ($t= 109.6$ and $p<.001$) and pair 8 ($t= 102.18$ and $p<.001$) showed the p-value to be less than 0.05 for all variables of the test. The result of paired samples t-test showed there is a statistically significant difference between the mean of bilateral anatomical shoulder movement strength among water polo players. It means that water polo players have a significant shoulder imbalance, and regarding the results of this test, water polo

players have a stronger right shoulder than their left shoulder due to their game play.

As depicted in Graph 3, the mean score of all right-hand variables among water polo players are greater than their similar movement of their left hand, suggesting that there is an anatomical shoulder movement strength imbalance among water polo players.

DISCUSSION

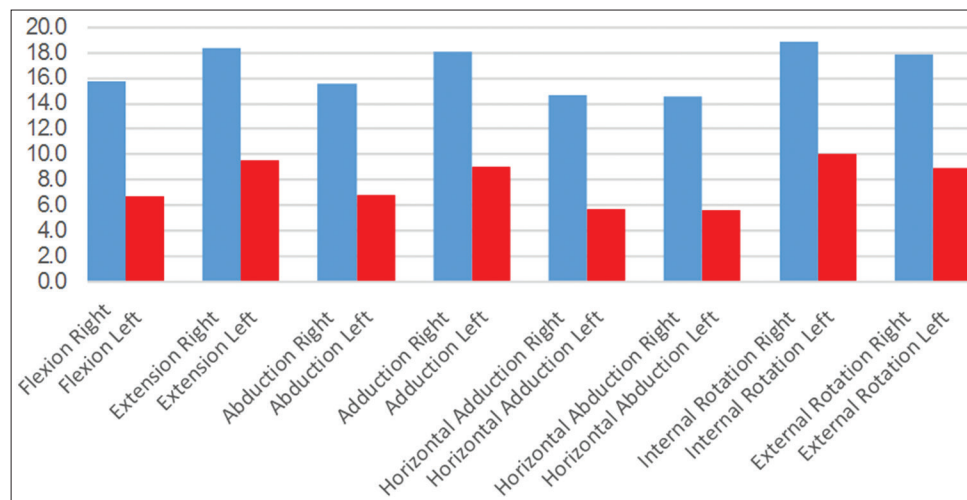
The findings of this study showed that the overhead players, who are water polo players in this study, suffer from anatomical shoulder movement strength imbalance due to more training and focus on their dominant hand. Considering these results, we understand that the water polo players had significant anterior and posterior shoulder strength imbalance in their shoulders. The results of this study showed that water polo players have stronger anterior shoulder muscles than their posterior shoulder muscles. This shoulder imbalance seems to be related to the players' aim of making stronger shots to score goals in the game, but unfortunately the athletes and coaches plan work-out more on deltoid anterior head, pectoralis major biceps brachia and serratus anterior than back muscles. If anterior shoulder muscles are stronger than the posterior shoulder muscles, it could lead to thoracic kyphosis problem among water polo players in future (Lewis, Green, & Wright, 2005; Page, Frank, & Lardner, 2009).

This study also showed that water polo players had significant anatomical shoulder movement strength imbalance on their right and left hands. According to the results, the right hand of water polo players was stronger than their left hand, hence this result showed all of the water polo players in this study suffered from bilateral shoulder imbalance.

Table 2. Comparison of Bilateral Anatomical Shoulder Movement Strength

	Mean	SD	T value	P value	
Flexion Right	15.8	2.3	136.09	<0.001	FL Right>FL Left
Flexion Left	6.68	2.5			
Extension Right	18.4	2.1	110.92	<0.001	EX Right>EX Left
Extension Left	9.52	2.4			
Abduction Right	15.6	2.2	121.89	<0.001	ABD Right>ABD Left
Abduction Left	6.86	2.4			
Adduction Right	18.1	2.4	101.47	<0.001	ADD Right>ADD Left
Adduction Left	9.06	2.9			
Horizontal Adduction Right	14.7	1.6	92.3	<0.001	HADD>HADD
Horizontal Adduction Left	5.65	2.1			
Horizontal Abduction Right	14.6	1.7	95.2	<0.001	HABD>HABD
Horizontal Abduction Left	5.64	2.2			
Internal Rotation Right	18.9	2.5	109.6	<0.001	IR Right>IR Left
Internal Rotation Left	10	3			
External Rotation Right	17.8	2.2	102.18	<0.001	EX Right>EX Left
External Rotation Left	8.91	2.7			

FL=flexion, EX=Extension, ABD=Abduction, ADD=Adduction, HADD=Horizontal Adduction, HABD=Horizontal Abduction, IR=Internal Rotation, EXR=External rotation



Graph 3. Comparison of Bilateral Shoulder Imbalance

ance. The results of this study proved that those traditional training of water polo can affect water polo players' shoulder and this shoulder imbalance can cause some mobility problems such as thoracic kyphosis, subacromial impingement syndrome and scoliosis in the future. (Lewis et al., 2005; Page et al., 2009). Moreover, this finding supports those of a study conducted by Edouard et al. (2013) regarding shoulder muscular imbalance among overhead players. their study revealed that overhead throwers suffered from shoulder muscular imbalance. Furthermore, the main finding of that research was that there was a relationship between higher dominant shoulder injury risk and an imbalanced muscular strength profile. The imbalanced muscular strength profile seems to be one of shoulder injury risk factors in overhead players. Players with muscular strength imbalance are two and a half times more likely to have a shoulder injury than those who do not have any such imbalance (Edouard et al., 2013).

This study was conducted in Malaysia and the participant in this study was province water polo players who were training together. Thus, we did not have a chance to test more players for this study. Additionally, some of the players were injured that could not include them in this study. The suggestion for future researcher to do the study for a higher number of players and also use Biodex Isokinetic dynamometer to get more accurate and reliable results.

CONCLUSION

The findings of this study can be utilized to develop game-specific strategic conditioning drills and to quantitatively demonstrate the physical and physiological demands of water polo. It is necessary to provide further quantification of the demands of water polo in different athletes, and of the effects of water polo training to reduce the issue of shoulder movement imbalance among overhead throwing players. It is also needed to establish valid and reliable tests to monitor and assess the shoulder imbalance of players, and to obtain the physiological and physical data for elite male athletes and develop players of both genders.

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