UNIVERSITI PUTRA MALAYSIA

EFFECT OF LAND AND AQUATIC MEDICINE BALL TRAINING ON SHOULDER IMBALANCE AMONG WATER POLO PLAYERS

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By

POOYA NEKOOEI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2020

DEDICATION

First and foremost, I wish to thank my parents (Mehdi Nekooei & Habibeh Rezvani) and my sisters for their love and support throughout my life. Thank you for giving me the strength to reach for the stars and chase my dreams. Also many thanks to my father-, mother- and sister-in-law who deserve my wholehearted appreciation as well.

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Also I give my deepest expression of love and appreciation to my adorable and lovely daughter Artemis who made my life brighter and became the only reason for me to finish my dissertation as soon as possible so that I could spend more time and play with her.

The bottom line is that without Sara's provocation, encouragement and occasional abuse, I would never have become any kind of sport scientist; and it is to her that I gratefully dedicate this dissertation.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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August 2020

Chairman : Associate Professor Y.M. Tengku Fadilah bte Tengku Kamalden, PhD
Faculty : Educational Studies

This study aimed to investigate the effect of land and aquatic medicine ball training on bilateral shoulder strength imbalance and their impact on throwing velocity and accuracy in male water polo players. The relationship of shoulder strength imbalance and anthropometric variables with throwing velocity and accuracy among water polo players was also examined. Participants in this study were Malaysian male elite water polo players (N=42), aged 16.79 ± 1.77 years old. They were randomly assigned equally to three groups (Aquatic and land training (n=14 for each) and a control group (n= 14) using the Fishbowl technique. A pretest and three posttests research design were used in the present study. The experimental groups for land and aquatic undergo same specific training on the non-dominant hand with gradually increasing load in every three weeks for 9 weeks (starting with normal water polo ball, 1kg and 2 kg medicine ball). This is an addition to their usual water polo training, while the control group only attended usual water polo training similar to the experimental groups. The training protocol used was the same for both land and aquatic training to evaluate the effect of training and different loads on shoulder imbalance rectification. After the completion of each three weeks of the intervention, eight tests of shoulder movement strength and two tests of throwing performance were administered to all participants to measure their changes in shoulder strength imbalance, throwing velocity and throwing accuracy. The paired sample t test of the pre test scores indicated that there were significant differences between the players' dominant hand and their non dominant hand in all eight shoulder movements strength for all players, where 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 Rotation (t= 109.6 and $p< .001$) and External

Rotation (t= 102.18 and *p*< *.001*). The results of repeated measures MANOVA showed a statistically significant difference in the mean test scores of shoulder strength imbalance in the pretest and 3 follow-up test measurements of both land and aquatic groups after 9 weeks non dominant hand training. Both experimental groups showed statistically significant improvement within and between groups on shoulder imbalance rectification. The results of between group comparison showed 93% for aquatic group and 43% for the land group's mean difference improvement from pretest to posttest. Throwing velocity and accuracy of the players showed significant improvement as well after 9 weeks of training. However, the improvement between land and aquatic groups in throwing velocity and accuracy were not significant. The findings of the study showed that water polo players have a tendency of bilateral shoulder imbalance which influence their throwing performance. The results also show that an intervention of specific training of 9 weeks of non-dominant hand by using medicine ball training on land and in water was effective in changing shoulder strength imbalance in the players. Hence, increasing water polo players' non-dominant hands' strength helps in rectifying the shoulder imbalance and these will be beneficial in improving their throwing performance.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KESAN LATIHAN BOLA PERUBATAN DI DARAT DAN AKUATIK KE ATAS KETIDAKSEIMBANGAN BAHU PEMAIN POLO AIR

Oleh

POOYA NEKOOEI

Ogos 2020

Pengerusi : Profesor Madya Y.M. Tengku Fadilah bte Tengku Kamalden, PhD
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Kajian ini bertujuan untuk mengkaji kesan latihan bola perubatan (juga dikenali sebagai bola segar) yang dilakukan di darat dan dalam air terhadap ketidakseimbangan kekuatan bahu dwisisi serta impaknya ke atas halaju dan ketepatan balingan dalam kalangan pemain sukan polo air lelaki. Hubungan antara ketidakseimbangan kekuatan bahu dan pemboleh ubah antropometrik ke atas halaju dan ketepatan balingan bagi pemain polo air turut dikaji. Subjek kajian terdiri dari pemain polo air elit lelaki warganegara Malaysia (N = 42) yang berumur (16.79 ± 1.77) tahun. Subjek telah dibahagikan secara rawak kepada tiga kumpulan yang sama bilangan ahlinya (latihan darat dan akuatik (n=14 untuk setiap satu) dan kumpulan kawalan (n=14)) menggunakan teknik 'Fishbowl'. Reka bentuk penyiasatan melibatkan satu pra-ujian dan tiga pos-ujian. Kumpulan eksperimental (darat dan akuatik) akan melalui latihan spesifik menggunakan tangan bukan dominan dengan peningkatan berat beban secara beransur-ansur (bermula dengan bola polo air, bola perubatan berberat 1 kg dan 2 kg) bagi tempoh 9 minggu (3 minggu setiap jenis rawatan bola). Latihan ini adalah tambahan kepada latihan lazim yang sedia ada. Manakala, kumpulan kawalan hanya menjalankan latihan lazim polo air yang sama seperti kumpulan eksperimen. Protokol latihan yang sama bagi latihan di darat dan akuatik digunakan bagi menilai kesan daripada latihan dan perbezaan berat beban yang digunakan terhadap rektifikasi ketidakseimbangan bahu. Setelah tamat setiap tiga minggu latihan, lapan jenis ujian dijalankan untuk mengukur kekuatan pergerakan pada bahu dan dua ujian mengukur prestasi balingan bagi mengukur perubahan pada ketidakseimbangan kekuatan bahu, halaju dan ketepatan balingan. Ujian-t bebas ke atas skor pra-ujian membuktikan terdapat perbezaan yang signifikan di antara tangan dominan dan bukan dominan dalam kekuatan kesemua lapan pergerakkan bahu dan bacaan adalah *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 Rotation* (t= 109.6 and *p*< *.001*) and *External Rotation* (t= 102.18 and *p*< *.001*). Keputusan analisis MANOVA menunjukkan terdapat perbezaan yang signifikan dalam purata skor ujian ketidakseimbangan kekuatan bahu bagi pra ujian dan tiga ujian susulan dalam kumpulan eksperimental, selepas mereka menjalani 9 minggu latihan bola perubatan menggunakan tangan bukan dominan. Kedua-dua kumpulan eksperimental juga telah menunjukkan peningkatan pada rektifikasi ketidakseimbangan bahu dalam kumpulan dan juga antara kumpulan. Bila dibandingkan purata perbezaaan diantara kumpulan darat dan akuatik, kumpulan akuatik menunjukkan 93% peningkatan yang lebih tinggi dan pantas berbanding dengan kumpulan darat yang hanya menunjukkan peningkatan sebanyak 43%. Tetapi, halaju dan ketepatan balingan oleh pemain turut menunjukkan perubahan yang signifikan selepas 9 minggu pemain menjalani latihan antara kumpulan darat dan akuatik. Dapatan kajian ini menunjukkan bahawa pemain polo air mempunyai kecenderungan untuk mengalami ketidakseimbangan bahu dwisisi dan ini mempunyai kesan kepada pretasi balingan. Keputusan ini menunjukkan bahawa intervensi latihan di darat dan akuatik selama 9 minggu ke atas tangan bukan dominan dengan menggunakan bola perubatan adalah berkesan untuk mengubah ketidakseimbangan kekuatan bahu. Oleh yang demikian, peningkatan dalam kekuatan tangan bukan dominan bagi pemain sukan polo air membantu dalam rektifikasi ketidakseimbangan pada bahu dan ini akan memanfaatkan dan membantu memperbaiki pretasi balingan pemain.

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My sincere appreciation also goes to all the water polo players involved in this experimental study as well as Kuala Lumpur and Selangor water polo association that helped me to train and collect data from their athletes.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

WAnT	Wingate Anaerobic Test
MPWAnT	Maximum power Wingate Anaerobic Test
HDD	Hand-held dynamometry

CHAPTER 1

INTRODUCTION

In this chapter the introduction for the research, the problem addressed in the study, research objectives, research questions, hypotheses are presented.

1.1 Introduction

Water polo is a team sport that involves 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 (Ferragut et al., 2011; Garbolewski & Starosta, 2002; Stevens et al., 2010; van der Wende, 2005). Although water polo has been played for more than a century, and the rules have evolved over time yet the essence of this sport remains completely unchanged (Platanou & Geladas, 2006). Most focus has been placed on the strategic, technical, and physiological requirements of water polo, and there were few studies on the anatomical and biomechanical movement of water polo.

A water polo is a sport that involves complex skills in which athlete attempts to score a goal by throwing the ball fast and accurate as possible as they can. So, like most other land sports they have firm surface to push off on but in water polo there is not that form surface, there is water and there is nothing to push off on. Furthermore ,the analyses of water polo game have shown that water polo is an intermittent sport which consists of intensive bursts of activity with the duration of over 15 seconds along with intervening, low intensity intervals with the average duration of over 20 seconds (Melchiorri et al., 2010; Smith & Norris, 1989). The measurements of physiological parameters during the game showed the cumulative effect in frequent series of physical activity and indicate that there is a high metabolic requirement on players. For a water polo player, there are multiple individual skills, as well as some neuromuscular requirements for the players. Previous research showed water polo players playing with their maximum capacity in high intensity situation, thus researching on body posture and anatomical measurement are important.

One of the most important skills in water polo is throwing the ball toward the opponent's goal post. During water polo game, players have to be able to throw the ball fast and accurate toward their opponents' goal and get point. The concerns of water polo coaches are 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 players. But the important part of throwing performance does not only focus on power but the shoulder

imbalance and limited internal/external Glenohumeral rotations as these may play an important role in throwing performance (Wang et al., 2000).

The throwing performance is a fundamental technical skill in many team sports including water polo, because a water polo player needs to have high anaerobic and muscular power for having a higher throwing velocity with good accuracy during the game. There are several factors that can influence the water polo performance such as throwing style, water jump and shoulder strength and stability. Water jumping and throwing performance are the most decisive skills reported by researchers (McCluskey et al., 2010; Stevens et al., 2010; van der Wende, 2005). However, throwing style is one of the most debatable skills among water polo coaches, because the style of shooting may affect throwing velocity and accuracy among all overhead players (Solum, 2016). Finest throwing styles require experience as well as knowledge about the anthropometric parameters and stability in shoulder. These abilities are contributed by advantageous anthropometric parameters to enhance the shoulder balance and power among water polo player (Solum, 2011).

Throwing performance is the combination of five shoulder movement, 1. preparation 2. backswing 3.forward motion 4. release 5. The fall through. In the preparation phase player must use the shoulders and trunk rotation to produce maximum power for his throwing, so having stability between right and left shoulders are very important (Solum, 2016). Players with stability in their shoulders and trunk can control their style and maintain their body posture during the other shooting phase. Players and coaches alike know that shoulder strength balance is one of the most important factors in achieving high speed and accurate throwing during the throwing execution. 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 to execute a great shooting performance but having bilateral imbalance between these movements may reduce the ball velocity and accuracy in water polo shooting procedure due to inappropriate shoulder and trunk rotation in first phase of shooting (Solum, 2016). The other factor that can effect throwing performance is anthropometric parameter, studying the anthropometric parameters of elite water polo players is very fundamental for all researchers because these parameters have strong relationships with the performance and physical capacity of players (Alcaraz et al., 2011; Aleksandrovi et al., 2007; Donev & Aleksandrović, 2008; Ferragut et al., 2011; Frenkl et al., 2001; Lozovina & Pavicic, 2004; Tan et al., 2009).

Since the ancient Greeks, coaches and athletes have always sought new methods and techniques to improve speed and strength, combined speed and strength result in power, and power is essential to the performance of many sport skills that involve throwing performance (Ramos Veliz et al., 2014; Saez de Villarreal et al., 2015). Although specific exercises such as medicine ball exercise designed to enhance power have been around for

some time, it has only been in the last decade that a system has emerged with emphasis on these types of training. In previous studies, researcher had used medicine ball for improving the water polo players shooting and passing skills strength and also used it as a treatment in their shoulder and back pain (Bloomfield et al., 1990; Marques et al., 2012; Van Den Tillaar & Marques, 2013).

Nowadays almost all studies and training 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, those studies only focus on the dominant hand of players because they believe that the non-dominant 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 dominant hand. Furthermore, all these trainings are only designed for dominant hand of overhead throwers and need a specific place and equipment, so these kinds of trainings lead water polo players to have bilateral shoulder strength imbalance.

Moreover, in the most sports players can hold the ball with two hand but in water polo players are not allow to hold the ball with two hands and 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 must throw, defend and train using their dominant hand, and this resulted in them becoming a one-sided player. Being one-sided, means that players are stronger in one side of their body than the other side, so they prefer to use their stronger side more than weaker side in their game play. Therefore, these shoulder strength imbalance will lead players to have injuries and problems such as back pain, shoulder pain and limited internal/external glenohumeral rotations. These pains and shoulder strength imbalance have a negative effect on players' performance (Aliprandi et al., 2013; Wang & Cochrane, 2001).

Even though athletes participating in the sports try as much as they can to avoid injuries, it is almost impossible due the nature of the sports which is the existence of one-sided player. Efforts to reduce injury of the players through proper training programme will be a key to their success in this sport. In overhead sports such as water polo, there is a high risk of shoulder injuries since the shoulder undergoes high forces and loads during throwing and defending (Clarsen et al., 2014; Hams et al., 2018; Miller et al., 2018). Strains are the most reported shoulder injuries, implying a process of overload over time that leads to injury (Abrams & Safran, 2011). The major problems that all overarm players face are shoulder and back pain, especially in water polo players. In water polo, players always throw, pass and defend the ball with their dominant hand and all their trainings are focused on their dominant hand, so they do work less or not at all on their non-dominant hand during training (Aliprandi et al., 2013; Wang et al., 2000).

Therefore, the main focus of this research is to find the effect of 9 weeks' land and aquatic medicine ball training with gradually load increase on shoulder strength imbalance and its effect on throwing performance among water polo players. The velocity and accuracy of the shots are the most important factors in every water polo game. So, research on the factors that may effect on throwing performance is crucial and needed. Balance in bilateral shoulder strength and internal/external rotation strength are the variables that may affect throwing performance (Hams et al., 2019). This study, evaluates the effect of Shoulder strength imbalance on throwing performance and the effectiveness of nine weeks of specific medicine ball training on reducing the shoulder strength imbalance, possibly improving throwing performance and reducing future shoulder injury among water polo players.

1.2 Problem Statement

Water polo is a complicated game and requires a lot of movement and muscle contraction. The players must swim short distance sprints in small areas with fast explosive movement and have a high accuracy to pass and shoot the ball while keeping their balance in the deep water. Additionally, due to the small size of the game playing area, shot accuracy and speed are very important for water polo players and in the coaches' perspectives to succeed in championships. Players with powerful and accurate shots would be the most effective players in any water polo team. However previous research mentioned that throwing performance can be effected by the shoulder asymmetric or shoulder impingement, they mentioned that shoulder pain that is the results of shoulder asymmetry are the main factor that effect on athletes throwing performance (Lewis et al., 2005; Mascarin et al., 2017; Page, 2011).

Additionally, the most important problem that all overhead throwers are faced with is shoulder strength imbalance such as limited internal/external Glenohumeral rotations (Kibler et al., 2012) and this problem may affect their throwing performance at the time and lead them to get a pack and shoulder pain in the future. The shoulder 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; Edouard, Codine, et al., 2013; Milano & Grasso, 2014; Mota & Ribeiro, 2012).

There are many researches about water polo performance and trainings to improve throwing accuracy and velocity (Andrade Mdos et al., 2013; Clements et al., 2001), but still there is a gap in the literature about the effects of bilateral shoulder strength imbalance on overhead throwing performance. Bilateral shoulder imbalance is important for water polo players as they are only focused to improve their dominant hand, thus exposing themselves to shoulder strength imbalance position. Moreover, there is very little research

that exactly shows the relationship between anthropometric parameters and throwing performance among water polo players.

So, in the current study, researcher was evaluating the effect of bilateral shoulder muscle imbalance on water polo players throwing performance and also provide an 9 weeks medicine training to reduce their bilateral shoulder imbalance who will lead player to improve their throwing performance. The reason that researcher choose water polo players is because, water polo is one of the unique sports that players have to use their hand while their body is not in the stable position. So, the importance of bilateral shoulder imbalance vividly effects on their performance. Furthermore, the nature of water polo and the rules of the game resulted in all water polo players one-sided feature, due to forbidden to use their both hands above the water at the same time (Smith, 1998). Moreover, due to lack of facility and usage of swimming pool for water polo players, therefore researcher compared two different training environments of aquatic and land exercises to evaluate the effect of experimental training in each of the training environment. Medicine ball was used in this research because medicine ball is the closest equipment to water polo normal training in and out of the water as well as it is the easiest and easily accessible strength training equipment that anyone can train with.

In the other hand, it is assumed that anthropometric parameters can have a relationship with throwing velocity in water polo players (Martínez et al., 2015). However, the other research gap in previous research is the lack of any validation norm or guidelines for the coaches to know which anthropometric measurement are the best for water polo players so that they could choose their players based on the best and useful anthropometric parameters. Finding the relationship between anthropometric parameters and throwing performance in water polo players can help us understand the ability of the players to play and perform in different positions of the game. This would be so important to understand because some of anthropometric parameters (e.g. heredity and length) cannot be changed with training, so the coaches should choose the players that naturally have these advantages (Knechtle et al., 2008; Martínez et al., 2015).

1.3 Significant of the Study

Several studies have been conducted on the water polo training and throwing performance but most of them were descriptive and just confirmed that there is a imbalance among overhead players or there is relation between shoulder asymmetry and players performance (Lewis et al., 2005; Mascarin et al., 2017; Page, 2011). Despite these beneficial findings, not enough studies have been undertaken to evaluate the effect of bilateral shoulder muscle imbalance among water polo players and the effect of it on players throwing velocity and accuracy. Furthermore, there is not any study to provide training protocol practically to observe the effect of medicine ball training on bilateral

shoulder muscle imbalance rectifications. The results of the current study can contribute to designing effective interventions for all overhead players.

The contribution of this study is the development of a training protocol for "rectifying bilateral shoulder imbalance" by taking into consideration factors related to a different environment (Aquatic and Land) and also different loads of training. Using the constructs of strength training as strategies to design an intervention to physiologically and anatomically improve overhead athletes to change their inappropriate throwing style and training.

Results from this study can practically confirm the robustness of the Non dominant strength training in a different environment of training are rectifying the bilateral shoulder imbalance. Finding of this study are applicable to all water polo populations around the world who pursuing water polo game in professional level. The findings of this study showed all parameters involved that increase or decrease throwing velocity and accuracy among water polo players. A coach with abundant knowledge about anthropometric parameters and also great in strength training will be a bonus for the water polo teams to improve their performance while reducing the injury rate (Johansson et al., 2015; Miller et al., 2018). Therefore, this study is helpful for coaches to understand the importance of bilateral shoulder imbalance on players throwing performance and the relationship between specific anthropometric features. Hence, coaches may be able to choose the better players after assessing them according to the findings of the present study.

Also, from the results related to the relationship between the anthropometric parameters and throwing performance, the sport agencies can choose the best and highly talented players for water polo teams and invest their money on the right persons.

1.4 Objectives of the Study

The main objective of this study is to examine the effectiveness of nine weeks land and aquatic medicine ball training on shoulder strength imbalance and throwing performance among water polo players. In the current study, there are also six specific objectives presented in the following section.

1.4.1 Specific Objectives of the Study

The specific objectives of the study are extracted from the main objective of the study and are explained as follow.

1. To examine the correlation between anthropometric parameters and throwing performance among water polo players in pretest.

2. To investigate if there are the differences in bilateral shoulder strength across all players at pretest.
3. To investigate the correlation between bilateral shoulder strength imbalance and throwing velocity/accuracy among water polo players in pretest.
4. To evaluate the within group effect of three different medicine ball training loads on bilateral shoulder strength imbalance among water polo players.
5. To evaluate the effect of land and aquatic medicine ball trainings on bilateral shoulder strength imbalance among water polo players.
6. To compare the effect of nine weeks training on throwing velocity and accuracy among water polo players.

1.5 Research Hypotheses

All the hypotheses of this study are null hypotheses. They reflect that there is no observed effect for our experiment. In the anthropometric hypotheses of this research, there are 21 independent variables and two (2) dependent variables (throwing performance) that are measured one by one with each independent variable by the researcher.

The anthropometric parameters are as follows:

Length: Palm Length, Hand Length, Height Length, Buttock-Leg Length, Buttock-Knee Length, Foot Length, Arm Spam Length. **Girth**: Wrist Girth, Forearm Girth, Arm Girth, Arm Flex Girth, Superior Thigh, Med Superior, Chest Girth. **Breadth**: Biacromial Breadth, Biliocristal Breadth, Wrist Breadth, **Physical characteristics:** Weight, Height and body fat percentage and BMI.

The hypotheses of this study are as below:

H_{01}: There is no significant association between each of anthropometric parameters and throwing performance in pretest among all players.

H_{02}: There is no significant difference in bilateral shoulder strength across all players at pretest.

H_{03}: There is no significant association between bilateral shoulder strength imbalance and throwing velocity/accuracy across all players at pretest.

H_{04}: There is no significant difference among three medicine ball training loads schemes on water polo players' bilateral shoulder strength imbalance after nine weeks of training.

H_{05}: There is no significant difference between Land and Aquatic medicine ball training on water polo players' bilateral shoulder strength imbalance after nine weeks of training.

H_{06}: There is no significant differences between and within groups on dominant hand throwing velocity and accuracy after nine weeks training.

1.6 Delimitation

There are some delimitations of the study that are set by researchers and are as follows:

- The water polo training procedure was controlled by the researcher.
- The researcher determined the swimwear used during the test.
- Participants were not allowed to use any supplements during the research.
- Participants were not allowed to undergo other strength training than the training used in this research.
- Three groups of participants had the same water polo training protocol in the same swimming pool.
- The swimming pool was outside, the weather and water temperature were based on daily weather but maintained for all participants.
- The water polo training was three sessions per week for all participants.
- They train together at the same time and swimming pool.

1.7 Limitations

The current research provided some useful understandings into influencing factors to shoulder muscle imbalance throwing performance of Water polo players, nevertheless, there are some limitations that was considered which are as follows.

- Participants did not show up for training.
- Participants did not follow the protocol with their maximum effort.
- Participants were injured during training.
- Participants quit midway through the experiment.

1.8 Definition of Key Terms

1.8.1 Anthropometric Measurements:

They refer to “a set of noninvasive, quantitative techniques for determining an individual's body fat composition by measuring, recording, and analyzing specific dimensions of the body, such as height and weight; skin-fold thickness; and bodily circumference at the waist, hip, and chest” (Ernst, 2010).

1.9 Operational Definition of Terms

1.9.1 Anatomical Shoulder Movement

The 8-kinesiology movement in shoulder joints such as flexion, extension, abduction, adduction, horizontal abduction, horizontal adduction and internal/external rotation.

1.9.2 Shoulder Strength

Shoulder strength is measured at all the 8-kinesiology movement in shoulder joints such as flexion, extension, abduction, adduction, horizontal abduction, horizontal adduction and internal/external rotation. The strength of these movements was measured by a hand-held dynamometer device.

1.9.3 Shoulder Strength Imbalance

The strength difference between dominant hand and non-dominant hand in all the anatomical shoulder movement is called bilateral shoulder strength Imbalance. Researcher measures shoulder strength of the dominant and non-dominant hand then calculates the difference between the dominant and non-dominant hand strength for each movement.

1.9.4 Dominant Hand

Hand dominance is defined as preferring one hand in performing fine and gross motor tasks, such as writing, cutting or catching and throwing a ball. In this study, the dominant hand is the hand that players use to perform shooting and passing during the water polo game and that is their right hand as all of our players were right hand player in this study.

1.9.5 Medicine Ball Training

A medicine ball is also known as an exercise ball, a med ball, or a fitness ball. Medicine balls are weighted balls with the diameter of the standard water polo balls, often used for rehabilitation and strength training. The medicine balls have the range of weight from 1kg above. The standard Mikasa water polo medicine ball weighing 1 kg and 2 kg were used in the present study. The medicine ball training in this study was done for land and aquatic training.

1.9.6 Throwing Performance

Throwing performance is the ability of a player to throw the ball in an accurate way with highest speed of the ball. In the present study, throwing performance was divided into two different throwing skills: throwing velocity and throwing accuracy.

1.9.7 Throwing Velocity

Throwing velocity is the highest speed of the ball the moment it is released from the player's hand. In this study, the maximum speed was measured by a standard sports radar gun.

1.9.8 Throwing Accuracy

Throwing accuracy in water polo means that the ball is thrown to the exact point of the goal or another player's hand. In this study, throwing accuracy was measured by a standard cover that covered the whole goal except five roughly ball-sized holes in it. Players were required to try and shoot the ball through the holes on the cover.

1.9.9 Duration in Main Training

In this study the follow-up tests are named as Posttest 1 to Posttest 3. Time one refer to Pretest that were done before main training starts, Posttest 1 is refer to the measurement that were done after 3 weeks training with normal water polo ball, Posttest 2 is refer to the measurement that were done after 3 weeks training with medicine ball 1 Kg and Posttest 3 is refer to the measurement that were done after 3 weeks training with medicine ball 2 Kg.

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